POWER

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ACTION!

● AS THIS IS WRITTEN, a cold March rain falls on soggy ground patched with snow. When you read it the sun may be shining (*will* be, if you live in California). But weather is just stage setting these days, setting for the most spectacular drama since the War. We are viewing scene one of "The Turn of a Century."

● ACTION HAS FOLLOWED action in Washington with breath-taking speed. Banks died and were reborn; the beer taps were turned on; something was done about unemployment; a start was made on the tough job of saving the farmers; the road was cleared for a Federal budget cut of $900,000,000.

● BUSINESS, for the moment, shows little gain, but the stock of courage is up 100 per cent from Worcester to Walla Walla, from Duluth to Dallas, because the thing feared has happened and passed. Heels are on the ground, chins are up, immediate drastic *action* is the pass word from Atlantic to Pacific. And we believe it's the only word worth a hang in these times.

● *POWER* CANNOT pretend to predict with certainty the business trend for the next six months. We can merely say, and honestly, that the prospects look a lot better than they did a few months back.

● IN THE POWER FIELD itself, there are several predictions that can be made with reasonable safety. Millions of dollars will be spent by breweries. Some will rebuild; many will install modern equipment, including high-pressure boilers, stokers or pulverized coal, bleeder turbines and modern refrigeration.

● THE BUILDING OF municipal plants—steam and diesel—will be accelerated. Air conditioning will move ahead.

● FINALLY, the slightest upturn in business will pull power modernization plans off the shelf. "Buy nothing" edicts will be swept aside. Common sense will return and executives will be "able to afford" to save the money they should have been saving all along. Better late than never.

● THOUSANDS of obsolete power units are operating today and other thousands, "standing by," have been robbed of parts until they are useless. All of these will soon reach the junk pile by one route or another. Many owners will scrap obsolete equipment and save their plants. But some will let nature take her course until their entire factories become junk by failure to cut costs to a level where corporate existence is possible. This is still a free country and every man may choose which road he will follow.

New Beer—Old Power?

• In many states legal beer will start flowing about the time this number is mailed. Anticipating the event, *Power* outlined at some length, in its February and March numbers, the power-service problems of reopened breweries. Since then contacts with brewing executives have revealed that some of them stopped thinking of power problems in 1917. There are those, for example, who refer to 150 lb. as "high pressure." Under the circumstances this situation is excusable, but the fact remains that, if such antique notions are to determine the equipment of reopened breweries, the waste of power dollars will be appalling.

The only safe course is to put brewery power plants—both design and operation—in the hands of men who know power plants, vintage 1933.

A Pioneer Reports

• Men like courage and frankness. For both we hand the palm to the Philip Carey Company. It took courage to install the highest pressure plant in America—"Plant Carey" at Lockland, Ohio. It took more courage to use reciprocating engines for these unprecedented steam conditions. Troubles were predicted and encountered. With resourcefulness they were overcome. With the utmost frankness they are recounted in the leading article of this issue.

Power men will like this plain talk, because it holds more practical meat than the Pollyanna tales of engineering beds of roses. We thank the Philip Carey Company and its engineers for letting *Power* bring this story to its readers.

Wages, Prices, Profits

• Economists predict a steady rise in wages for several years at least, with no equivalent rise in prices. What then will happen to industrial profits? It all depends.

Clearly, the factory that cannot cut waste will have no future under these conditions. Those that can will. In this waste-cutting picture, the power engineer has an important position. Better use of power and productive machines will cut labor waste. Better metering and charging of power services will cut consumption waste. Better equipment, hook-ups and operation will greatly lower the unit cost of power services.

The dawning new day is a challenge to every power engineer who seeks personal advancement through the utmost contribution to the industry he serves.

The Power Frontier

• Two years ago (May 26, 1931) *Power* published the first and only exhaustive table of current research in this field. This pioneer effort filled a great need, as reader response proved. But the world moves on and the field calls for a new summary of research progress since 1931. This will appear in the May number, where a 20-page table will sum up reports collected from 130 institutions in America and abroad.

To make a balanced diet, the remaining space will be devoted to twenty short and intensely practical articles, covering as many phases of daily plant operation. Every reader will find something that he can use in May *Power*.

Do You Inhale?

• While cigarette manufacturers are airing the "delicate" question, "Do You Inhale?" don't forget your compressors and gas and oil engines. They do. In the course of a week many tons of air enter the cylinders of an average-sized engine or compressor. With it come several pounds of dust, dirt, muck, to score cylinders, increase maintenance and lower efficiency.

The only cure is filtered air. Reliable air filters for every service are available, and it costs less to install them than leave them off. Why take a chance?

Practical

• *Power's* Aims Are: Practical information, full power-field coverage, concise presentation, plain speaking without frills, honest comment, vision tempered by common sense. The magazine is published to serve the bread-and-butter needs of practical power men. Study the pages that follow.

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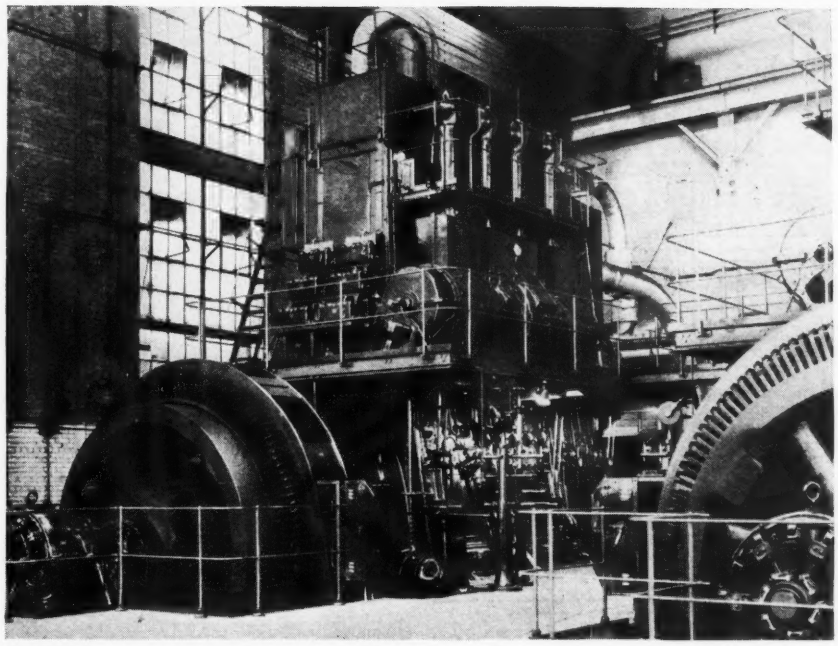
1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases

POWER Stands for

5. Better Use of By-product Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application
8. Prevention of Smoke, Within Reason



PLANT Carey, designed for 1840-lb. pressure and 797-deg. steam temperature, is the highest pressure commercial power plant in the United States and is a pioneer in the use of reciprocating engines under these steam conditions. Solution of the various operating problems frankly related in this article indicates that it is practicable to use reciprocating engines with high-pressure and high-temperature steam

OPERATING EXPERIENCE WITH 1800-lb. STEAM at PLANT CAREY

By H. P. STEPHENSON*

Power Engineer, The Philip Carey Co.

THE power plant of The Philip Carey Company, at Lockland, Ohio, started preliminary operation May 3, 1931, and was placed in continuous commercial operation in December of that year. The plant has been carrying the entire manufacturing electric and steam load since that time. It holds the distinction of being the highest pressure commercial plant in the United States, and contains the only reciprocating engines operating with steam at 1,500-lb. pressure and 780-deg. temperature.

The Philip Carey Company manufacture a variety of power and building materials, including asbestos and magnesia heat insulations, asphalt paints and pitches, asphalt waterproofings, felts, roofings, industrial flooring, expansion joints, etc. They operate a number of plants including asbestos properties in Canada.

As has been the case in all pioneer plant developments, certain expected and some unexpected operating difficulties have been encountered in Plant Carey. The major problems have been solved, but before discussing them the features of the plant will be briefly recalled.

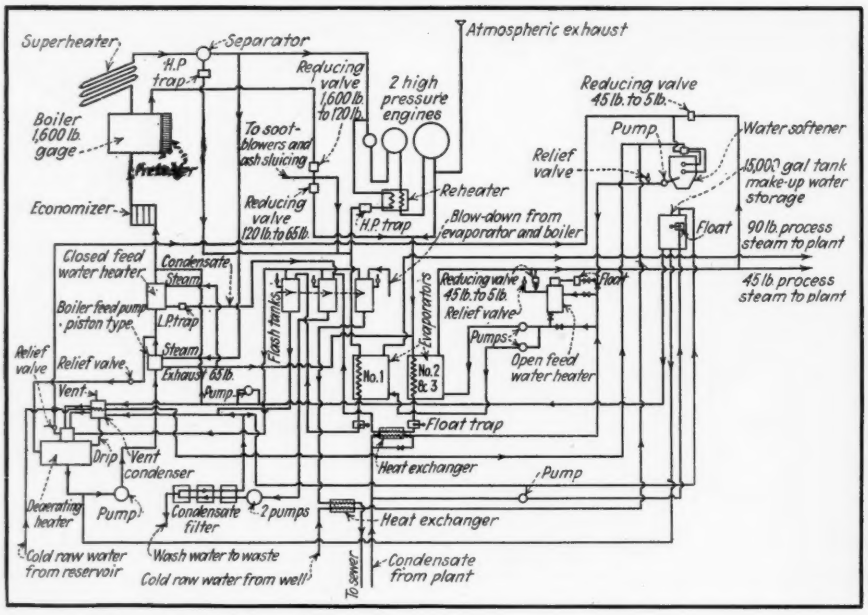
Two cross-drum boilers, rated at 150,000 lb. per hr. each, generate steam at 1,550 to 1,750 lb. pressure and 780 deg. F. Fin-tube water walls surround the 9,700-cu. ft. furnaces. At the rated output of 150,000 lb. per hr., the heat liberation is approximately 20,000 B.t.u. per cu. ft. per hr. Economizers having 5,930 sq. ft. of heating surface and 20,148 sq.ft. tubular air preheaters are provided for each boiler, the latter supplying secondary air at 350 deg. Each boiler is fired by four tangential burners and is served by four 1.8-ton-per-hr. pulverizer mills. The furnaces have dry bottoms of stepped design to facilitate disposal of ash through a sluicing trough at the rear of the boilers.

The two 3,750-kw., triple-expansion, vertical engines, operating at 225 r.p.m., receive steam at 1,500-lb. pressure and exhaust to evaporators at 65-lb. pressure. These units were designed for a throttle pressure of 100 kg. per sq.cm. (1,422 lb. per sq.in.) and a steam temperature of 425 deg. C. (797 deg. F.). The normal operating pressure, however, is approximately 1,500 lb. This pressure is reduced at very low loads and is occasionally increased to 1,600 or 1,650 lb. at full load when necessary to balance the supply of exhaust with the demand for process steam. Each engine has two single-acting, 14½-in. diam., high-pressure cylinders, two single-acting, 21¼-in. diam., intermediate cylinders and one double-acting, 25⅝-in. diam., low-pressure cylinder. The high-pressure cylinders are above the intermediates.

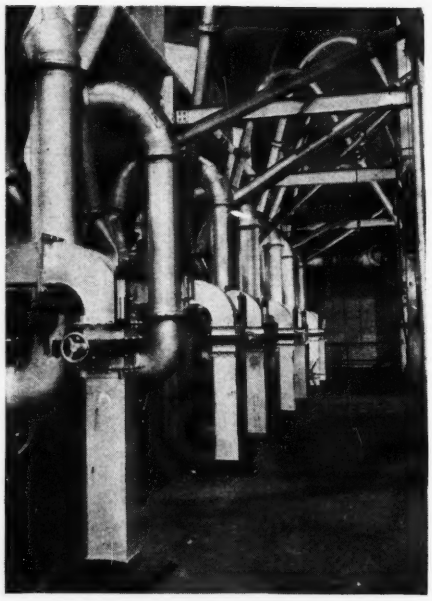
The two high-pressure pistons operate downward and the two intermediates operate upward on the same piston rods, so that the engines have only three cranks. Steam from the intermediate cylinders is reheated to 526 deg. in live steam reheaters located at the engine, before going to the low-pressure cylinders.

As will be seen from the flow diagram, exhaust steam at 65 lb. pressure from the main engines and from the

*H. P. Stephenson, is a graduate of the University of California, a member of the A.S.M.E., and holds an unlimited chief engineer's marine license. He was senior first engineer on the S.S. *Leviathan* and has been in stationary power plant construction and operating work for the past twelve years.



Pressures given on this flow diagram refer to present operating conditions



Four unit pulverizers serve each of the two 150,000-lb.-per-hr. boilers

engine-driven feed pump is condensed in two 150,000-lb. per hr. evaporators which supply steam at 45-lb. pressure to processes in the manufacturing plant. The exhaust steam passes through an oil separator between the engine exhaust and the evaporator coils. A third evaporator receives condensate trapped from the live-steam reheater and from the separator in the main steam line and also is supplied with live steam through a reducing valve. This evaporator supplies 90-lb. process steam to the plant. Water to the evaporators is treated in a hot-process softener.

Condensate from the lower-pressure evaporators passes through three oil-removal filters in series before going to the deaerating and closed feed-water heaters. Steam at about 10-lb. pressure is supplied to the deaerating heater from flash tanks in the evaporator condensate lines. Sixty-five pound exhaust steam is used for heating the feed water in the closed heaters which are installed on the discharge side of the pumps. Make-up water, taken from uncontaminated process steam condensate, is introduced into the system at the deaerator.

Two centrifugal booster pumps take the feed water from the deaerating heater and deliver it to the suction of the main boiler feed pumps. Originally these pumps delivered the water at a pressure of 60 lb. per sq.in.; this pressure has been increased, as will be described later. The main pumps are horizontal triplex reciprocating units, one electrically driven by a variable-speed motor and one steam driven by means of a vertical-compound steam engine; this engine takes steam at full boiler pressure and exhausts at 65 lb. into the main exhaust header. Each pump will deliver 180,000 lb. of water per hr. at full speed. The inherent efficiency of this unit is enhanced by the fact that the water level in the boiler can be regulated entirely by controlling the governor of the boiler feed pump engine, and therefore, no resistance is necessary in the feed lines for purposes of regulation.

The first and most serious difficulty to arise in connection with the operation of the main engines was that the two machines could not be synchronized with each other or with the gasoline-engine driven unit which was installed for starting and standby service. Changes to the engine governors were only partially effective, but the addition of a flywheel and the installation of compensating coils in the generator winding completely removed this difficulty. The engines now operate satisfactorily in parallel with each other and with the gasoline engine, regardless of the distribution of load between the machines.

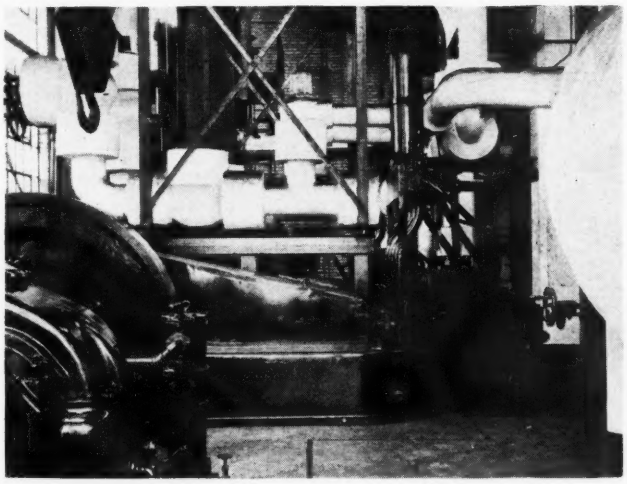
From the beginning, great difficulty was experienced with the lubrication of the high-pressure cylinders. Not only was it necessary to replace the piston rings at frequent intervals, but there was excessive wear on the cast-iron liners of the high-pressure cylinders. Much experimenting was done with various types and brands of piston rings and even with new designs of pistons, piston rings and liners. The solution of the lubricating problem was a gradual development, to which many factors contributed. The use of a longer or "plug" type piston apparently improved the alignment and gave better results than the disk type originally installed. The present piston is long enough for the use of eleven piston rings.

A multiplicity of oil holes in the high-pressure cylinder walls improved the distribution of oil over the surface of the cylinder liner. After the longer piston had been installed and the additional oil holes were in use, the cylinders appeared to be thoroughly lubricated when they were inspected between runs, but the wear of both rings and liners contined to be excessive. The wear on the liners was particularly objectionable; the rings were not expensive, and they could be replaced in a few hours, but replacement of the liners was a costly operation, requiring a more protracted shut-down. This naturally led to a search for a harder metal for the liners so that all the wear would be concentrated on the rings.

Within the past few months, a cast iron of greater hardness and more uniform structure has been secured. No change was made in the piston ring material, but the rings appear to wear much better with the new liners. Since the installation of these harder liners on one engine, there has been no appreciable increase in piston ring leakage. The wear on the liners during this period

has not been sufficient to remove entirely the original tool marks.

There is a balance chamber between the high and intermediate pistons which receives the leakage or blow-by from both cylinders. This construction made it possible to watch the condition of the rings by taking the leak-off through an external pipe in which an orifice was installed to measure the amount of leakage past the piston rings. In the original design, this chamber was connected to the exhaust pipe so that all leakage from the high and intermediate cylinders went directly to the process steam evaporators. An important step in the improvement of engine performance was the connection of this leak-off chamber to the inlet of the low-pressure cylinder, instead of to the exhaust. As the low-pressure cylinder takes steam at approximately 250 lb. pressure at full load, the pressure drop across the piston rings was materially reduced. It is believed that leakage past the rings has the effect of scouring away the cylinder oil just at the time and place that lubrication is most needed. When this change was made, the amount of piston ring leakage was reduced approximately one-third, the lubrication and general condition of the cylinders was improved and, moreover, this alteration improved the thermal efficiency of the engines by utilizing the leak-off in the low-pressure cylinder.



High-pressure feed water is supplied by two horizontal triplex pumps of 180,000-lb.-per-hr. capacity

Minor improvements to the engines have been the installation of a continuous centrifugal purifying system for the engine oil and the installation of pumps to handle the cylinder oil from the barrels in which it is delivered to the gravity tank on the roof, thus reducing the possibility of contaminating the cylinder oil. Also, steps were taken to prevent contamination of the engine oil by leakage from the cylinders. The piston rods were equipped with wiper rings to prevent leakage from draining into the crank case, but the chambers between these rings and the stuffing boxes were not properly vented and drained. Each chamber was provided with a vent to the atmosphere. Since this change, operation of wiper rings has been completely satisfactory.

Boiler Improvement

At first much trouble arose from the formation of slag on the water wall and screen tubes. Larger burner tips, also right-hand and left-hand deflector plates, were installed. With these changes and also with some changes in firing methods, especially air regulation, the formation of slag stopped.

The high temperature of water in the boilers and the resulting high temperature of the heating surface made it necessary to pay strict attention to treatment of feed water. The principal problem was scale formation due to contamination of the condensate used for feed water, and difficulties occasioned by the presence of oil in the boiler feed water due to the failure of oil removal devices to function effectively.

In passing through the engines, the steam picks up a great deal of cylinder oil. Exhaust steam passes through a baffled separator designed to remove all but a trace of free oil. Next, the steam passes through coils of two evaporators and is there condensed. Three conical filters are provided for the final clarification of the condensate. To coagulate the oil and facilitate its removal in the filters, alum and caustic soda are used. The effluent from these filters, which is supposed to be free from oil and scale-forming impurities, is then treated with phosphate as an antidote to corrosion and to soften any hard water which might accidentally get into the boiler feed system.

Originally a considerable quantity of oil passed both the separator and the oil removal filters. In addition to this, the quantity of calcium and magnesium present in the boilers indicated excessive contamination and resulted in scale formation. The scale formation was thin but, due to the high metal temperature, it furnished sufficient insulation to cause distortion and, in a few instances, failure of the water-wall tubes.

The oil separator was equipped with a water spray which did not function properly. The oil and water were not properly removed from this separator due to lack of capacity of the trap. The mixture of oil and water drained from the separator is delivered to a skimmer tank, where the greater portion of the oil is skimmed off. Originally, the oily water from the skimmer was returned to the oil removal filters, increasing the already heavy duty imposed upon them.

Improvements were made to the water spraying device in the oil separator and arrangements were made to use the effluent from the skimmer tank to supply this spray. A larger trap produced effective drainage. A larger skimmer resulted in increased recovery of cylinder oil, which is centrifuged and used for lubricating the low-pressure cylinder. The larger skimmer tank did not, however, sufficiently clarify the condensate so that it could be returned to the boiler feed system without overloading the oil filters. There is a material waste of heat as well as of clean water at this point, but it is hoped that this water may eventually be sufficiently clarified to be used for feed to the process evaporators.

After these changes, together with an increased pressure on the separator spray nozzles, the oil removal equipment eliminated practically all traces of oil in the water discharged from the filter. A turbidity indicator was made and installed in the discharge line. In this indicator a beam of light passes through the water. Small particles of alum floc or small globules of oil are thereby made visible, showing instantly any irregularity of filter operation.

Analyses of the feed water at various points in the system disclosed that the feed water increased in hardness in passing through the oil removal filter. This was due chiefly to leakage of backwash water into the filters, and this condition was corrected. It was then found that most of the remaining hardness entering the boilers

came from the filter material which was being dissolved by the condensate. This filter material was crushed dolomite rock and gravel with an upper layer of silica sand. This was replaced with magnetite ore. The latter was extremely difficult to obtain, but the Bethlehem Steel Company was finally prevailed upon to furnish the necessary material. The immediate drop in phosphate required to maintain proper excess in the boiler water indicated the success of this change.

The original method of feeding phosphate was by means of a proportioning feed tank, which fed continuously into the feed line. A small gear pump, operated by a time clock, was installed to permit intermittent feeding of phosphate. This has decreased deposits in feed lines and economizers.

Originally, make-up for the high-pressure feed system was provided by condensing 45-lb. steam in a special make-up condenser. The maintenance on this unit was excessive, due to the deposit of scale from the raw water which was used as a cooling medium. Accordingly, this condenser is now held purely for emergency service and the normal make-up is taken from the uncontaminated condensate of various process machines. Continuous check is made of this make-up to prevent the accidental introduction of hard water into the high-pressure system.

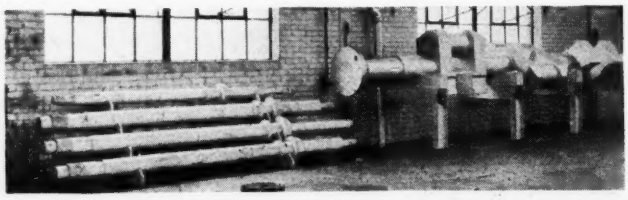
As originally installed, the superheaters did not produce the superheat for which the engines were designed, and for the first year of operation the average steam temperature was about 700 deg. F. Although this low temperature resulted in a material increase in the water rate of the engines, in view of the lubrication difficulties which were being experienced it was deemed unwise to increase the operating temperature. As soon as the lubricating problem became less acute, steps were taken to increase the superheat. This was accomplished largely by a rearrangement of the baffles. The present operating temperature averages 780 deg. F., and it is interesting to note that this increase in temperature has apparently had no adverse effect on lubrication or wear of the engine cylinders. The expected decrease in steam rate resulted.

Serious vibration in the feed lines was experienced at first, even at light loads. The discharge from each of the high-pressure pumps was equipped with an air chamber, but these air chambers were not effective because the water passing through the pump was completely deaerated and would absorb any gas that might be used. The air chambers were changed into steam chambers by installing coils in them. Superheated steam from the boilers is admitted to this coil and the outlet so throttled as to keep the chamber approximately half full of steam.

This change eliminated vibration at low pumping speed, but there was still objectionable vibration at high capacity. Further check of the operation of the pump showed that the booster pressure of 60 lb. was not sufficient to cause the water to follow the plungers on the suction stroke. Cavitation was plainly evident. A booster pump of the proper capacity, developing a discharge pressure of 225 lb., was transferred from the old boiler plant. When this was installed, vibration of the feed line was eliminated.

There has been practically nothing but routine maintenance required either for the main boiler feed pumps or for the steam engine drive. There has never been, at any time, any lubrication problem on the steam cylinders of the boiler feed pump engine.

For considerably more than a year this plant has been in commercial operation, carrying the entire load of the manufacturing plant. While the problems have been grave, and at times discouraging, the effort has been distinctly worth while. The reciprocating steam engine can produce more by-product power from small quantities of steam than any turbine which has yet been designed and the practicability of this type of prime mover for high steam pressures has been definitely demonstrated.



Because the main engines were made in Germany, spare crankshafts and connecting rods are kept available

ALUMINUM BROMIDE "BETTER THAN MERCURY"

THE second and third mercury-steam power plants now being erected in this country are outstanding examples of the practical results that may be obtained in the pursuit of a theoretical ideal. While other fluids than mercury have been considered for binary-cycle purposes, American engineers have, in general, agreed upon mercury as the only practical fluid for this purpose. However, this is a question that can never be considered settled.

Several years ago Dr. Koenemann, of Germany, pointed to the possibility of using "zinc ammoniacates" in a cycle in which this substance is continually broken up and recombined. The Koenemann cycle makes the power plant over into a chemical factory.

In this connection, an interesting proposal has just been made by Dr. H. Barjot, who has several times contributed to *Power* interesting and out-of-the-ordinary ideas for the generation of power. In the January, 1933, number of *Le Genie Civil* he proposed the use of anhydrous aluminum bromide as a fluid superior to mercury for binary-cycle power generation. In fact, Dr. Barjot states that this substance is the only one, other than mercury, which could be so used.

The formula for anhydrous aluminum bromide is $Al_2 Br_6$. Its melting point is 200 deg. F., and boiling point 500 deg.

The advantages listed are: non-poisonous vapor, ability to moisten iron (boiler tubes), visibility of escaping vapor, a vapor density double that of mercury (allowing low rotary speeds of turbine), lower cost, unlimited reserves of the constituents (aluminum and bromide). Dr. Barjot states that only about 22 lb. of the substance would be required per kilowatt of capacity, to cost $2.

The great affinity of this substance for water requires a special type of condenser boiler with a "triple-wall" device, the purpose of which is to prevent any possibility of contact between the condensing aluminum bromide and the contiguous boiling water, such as might occur through an accidental break. The diagrammatic hook-up is generally similar to that of the mercury-steam cycle.

Old Stand Pipe Becomes
UNIQUE COOLING TOWER

ROCKVILLE CENTRE, L. I., has just completed a new water tower adjacent to its municipal diesel plant. Instead of tearing the old stand pipe down, officials have converted it into a unique cooling tower, thus cutting demolition and erection costs while providing diesel jacket water at 60-ft. hydrostatic head.

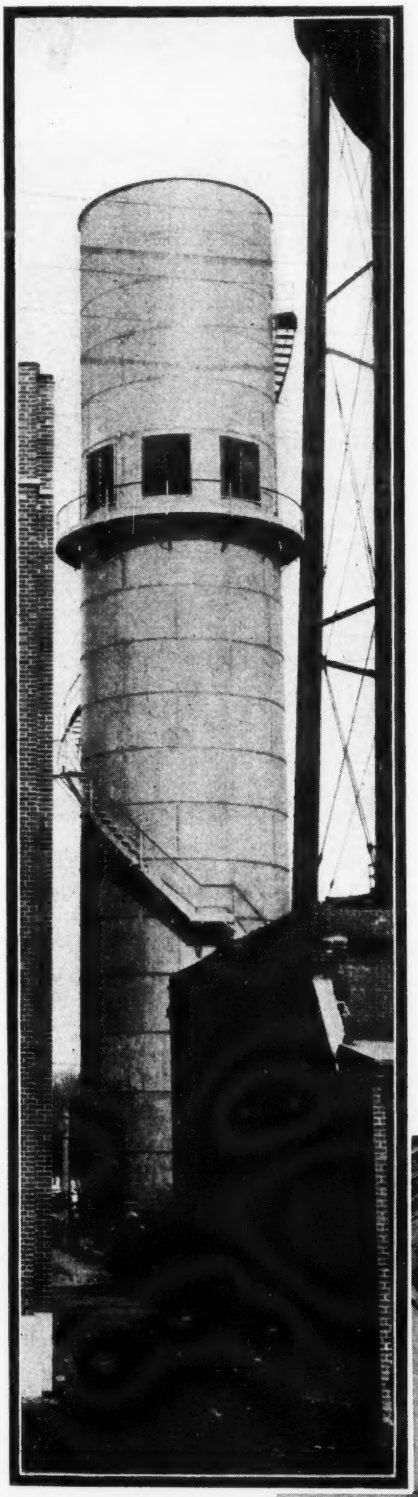
It is advantageous to have jacket water at a moderate pressure. This ordinarily requires two pumps, one to force water through the cylinder jackets, the other to force the heated water through the cooling system of the tower. Since the stand pipe was available, however, the lower 60 ft. was converted into a storage tank. A single pump, that for bringing heated water to the top of the cooling tower, thus handles the complete cooling cycle, while the 60-ft. hydrostatic head provides the added advantage of a large reserve of jacket water under pressure in case of pump failure.

The tower is of the induced draft type, with a 4-bladed propeller-type fan in the 20-ft. diameter top of the 100-ft. shell. The fan ring at the top of the stand pipe is riveted to a steel platform which effectively closes the space between the pipe and the fan ring, thus preventing any downflow of air. Laminated wood, Monel metal covered, is used for the 120-in. diameter fan, which is mounted directly on the shaft of a 20-hp. vertical motor. The vapor-proof motor is of the squirrel-cage induction type providing 2-speed operation and has a vaned housing for air cooling.

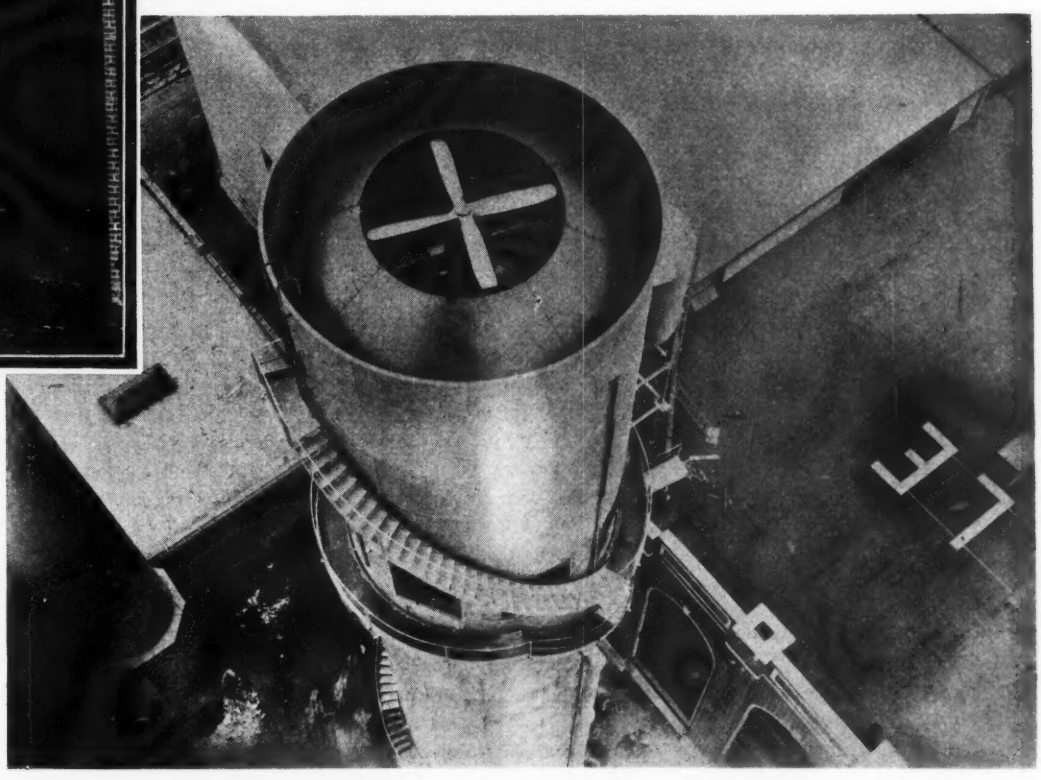
California redwood filling is placed in the upper section of the tower. All hardware is copper or bronze to avoid corrosion.

The tower is designed to circulate a maximum of 1,600 g.p.m. under extreme summer conditions, with the induced-draft fan operating at high speed. At low speed, 1,000 g.p.m. can be cooled from 120 to 90 deg., and with the same wet-bulb temperature the tower can cool 250 g.p.m. through the same temperature range on natural draft. Foster-Wheeler equipment was used.

A propeller-type fan is particularly suited for towers where some of the operation can be under natural draft because of the large opening for air flow when the fan is shut down.



The converted standpipe, showing the louvres about two-thirds of the way up through which cooling air is drawn.

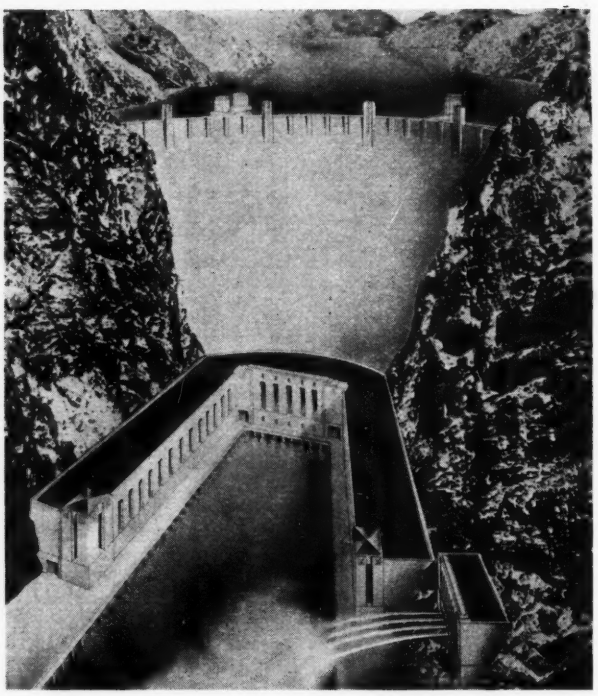


Looking down from the new water tank into the top of the cooling tower. The noiseless motor, hidden fan and lack of spray avoid complaint from nearby residents.

HOOVER DAM Hydro Plant

To House

LARGEST TURBINES



Initial installation will consist of five 115,000-hp. and two 55,000-hp. units, the plant being designed for an ultimate capacity of 1,835,000-hp. in 17 units. Bids for the turbines were opened March 10, but contracts had not been awarded when this number went to press

THE highest dam in the world, and one of the largest hydro-electric plants, with units of the greatest capacity, are included in the Hoover Dam project, 28 miles southeast of Las Vegas, Nev., on the Colorado River. The power plant, immediately downstream from the dam, is U-shaped, with the base of the U across the river on the downstream toe of the dam and one wing on each side of the river. Main generating units will be installed in the wings of the power plant, station service units and other control and auxiliary equipment being in the central or connecting portion.

The power plant is laid out for an ultimate installation of fifteen 50-cycle main generating units rated at 82,500 kw. each, and two 60-cycle of 40,000-kw. capacity each. The initial installation will comprise five of the large units and the two small ones. There is a possibility of future operation at 60 cycles, and the large units are being so designed that they may be changed to this service by installing new runners on the turbines.

In the storage reservoir, the water-surface elevation will fluctuate from a maximum of 1,229 to a minimum of about 1,050 ft. Under present conditions, the surface of the water in the river at the dam site, with a low-water flow of 12,000 sec.-ft., is at about elevation 647. With a discharge of 100,000 sec.-ft. the water surface in the river immediately below the dam is at elevation 666. It is expected that loose material in the river bed below the dam will be eroded gradually by the clear water released from the reservoir. This will result eventually in a lower tailwater elevation.

In order to provide for this possibility, the power plant is being designed for a minimum tailwater surface at elevation 625. The center line of the turbine runners will be at elevation 637, and the elevation of the water surface in the tailrace will vary from about 28 ft. above to about 12 ft. below this line. With channel conditions as they now are, the average elevation of the surface water in the tailrace will be from 10 to 12 ft. above the runner center line. The net effective head under which the turbines will operate may vary from a minimum of about 420 ft. to a maximum of 590 ft.

These extreme head conditions will occur only at infrequent intervals and will be of short duration. Ninety per cent of the time the net effective head will be between 450 and 560 ft. It is expected that the head on the turbines when first installed will be as low as 300 ft., and that it may be several months before the head is 420 ft.

Each large turbine is to have a capacity of not less than 90,000 hp. when operating at 150 r.p.m. under a net effective head of 420 ft. As the head increases above 420 ft., turbine output will increase to a maximum of 115,000 hp., corresponding to full generator rating of 82,500 kw. at unity power factor. Each small turbine is to be rated not less than 44,000 hp. when operating at 257 r.p.m. under an effective head of 420 ft. Under maximum head each unit is to have a rating of 55,000 hp., corresponding to full generator capacity of 40,000 kw. All turbine parts are to be designed and constructed to withstand stresses resulting from operation at no-load runaway speed under maximum head. Runners will be of the francis type, and made of cast steel.

Specifications require that the contractor guarantee the runners against excessive cavitation and pitting for one year from the date they are placed in service at heads of 420 ft. or higher. Excessive pitting is defined as the removal of runner metal aggregating 400 cu.in. or more.

A babbitted-line, oil-lubricated bearing will be located above the runner on each turbine. Each will consist of a bearing support and a removable bearing shell. This

bearing will be provided with two thermostat relays arranged in close contact upon a predetermined bearing temperature. Two dial-type temperature indicators, with the temperature detecting element embedded in the anti-friction metal of the bearing, will be installed, one near each end.

Two independent, motor-driven, positive-displacement rotary oil pumps will be provided for circulating lubricating oil. These pumps will be mounted separately at or near the main turbine floor level. Normally, the oil will be circulated by one pump driven by an alternating-current motor. On failure of oil pressure or the alternating-current supply, the second pump, driven by a direct-current motor supplied from a storage battery, will start automatically.

The spiral casings are to be made of cast steel and designed for a hydrostatic pressure of 300 lb. per sq.in. They are to be provided with four piezometer connections equally spaced around their inlet sections, where the flow conditions will be favorable for accurate measurement of the head. Four additional piezometer connections are to be provided, at locations to be determined by design details, for installing a flowmeter.

Renewable wearing rings are to be provided where there are close-running clearances between the runner and stationary parts of the turbine. On the runner the wearing rings are to be of stainless steel. Wearing rings on stationary parts are to be of a softer metal than the rotating rings. They are to be of a composition that will offer the maximum resistance to wear and the least liability to serious damage in the event of accidental contact between the rotating and stationary rings.

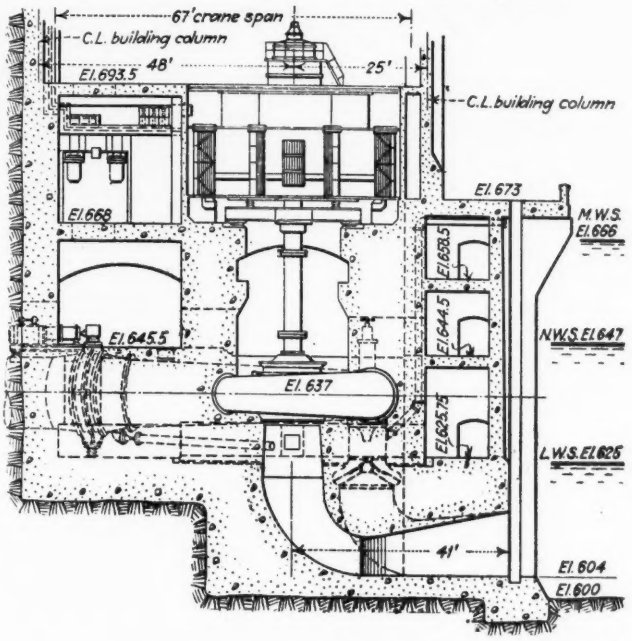
Each turbine is to be provided with a pressure regulator or relief valve. Its discharge capacity is to be not less than 80 per cent of the flow rejected by the turbine when full generator load is dropped at 590-ft. head. The pressure regulator valve is to be mechanically connected to the turbine-gate operating mechanism with a connection of sufficient strength to stall the servomotor if the pressure regulator valve sticks.

Acceptance tests on the turbine are to be conducted in accordance with the Test Code for hydraulic turbines, approved by the Machinery Builders Society, Oct. 11, 1917. The quantity of water passing through the turbine is to be determined by either the Gibson method or the Allan salt-velocity method, at the option of the Government.

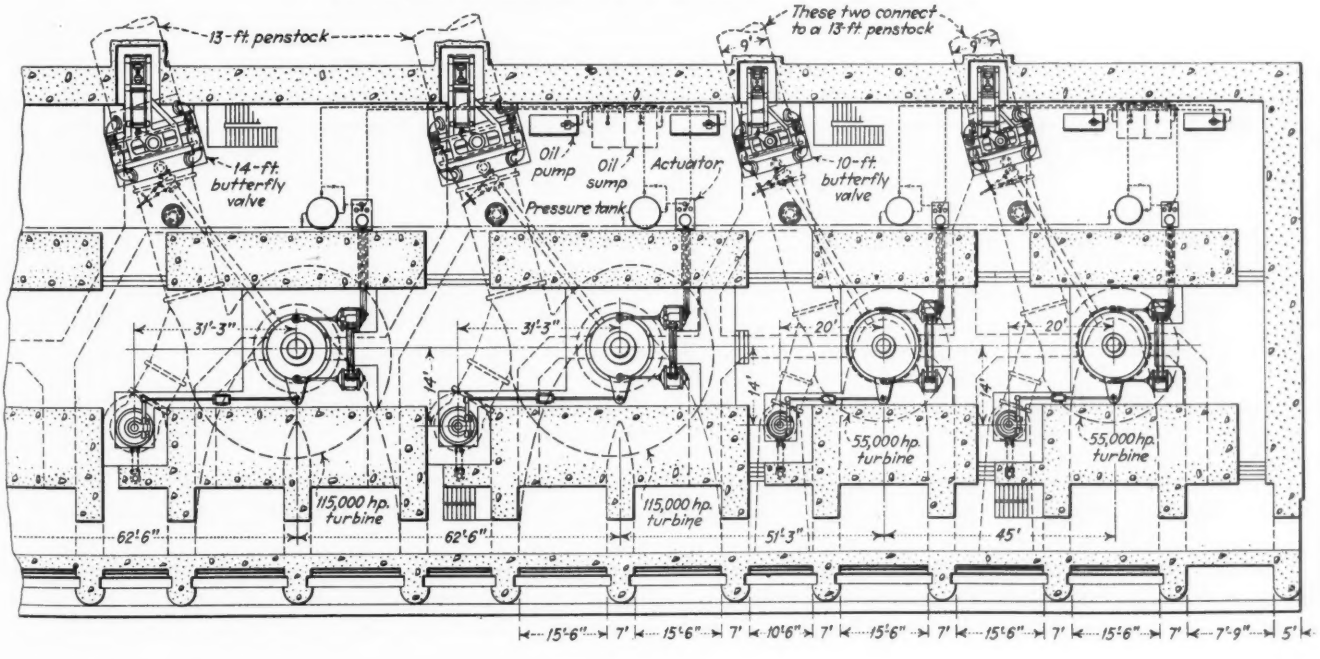
A butterfly-type shut-off valve 14 ft. in diameter is to be provided near each large turbine. A valve of the same type, 10 ft. in diameter, will be installed near each small turbine. These valves are to have vertical stems, and both the valve body and wicket are to have renewable seats, one or the other to be readily adjustable when the valve is in place.

Power is indebted to the United States Bureau of Reclamation for supplying specifications of the turbines from which the information in this article was taken. Design of the Hoover Dam project is being made by, and supervision of its construction is in charge of this Bureau.

Cross-section through one of the 115,000-hp. units



Partial plan of turbine-room floor in Arizona wing of power house



REFRIGERATING PLANT OPERATING TROUBLES

Their Causes and Cures

By LEON BUEHLER, JR.
Frick Company

Operating troubles in the refrigerating plant fall into two classes: mechanical troubles and troubles in the refrigerating cycle due to faulty or impure refrigerant or impaired functioning of heat-transfer apparatus. Mechanical troubles announce themselves by hot bearings, knocks or breakage of parts. This article deals only with the second class, where troubles are more elusive and where corrective measures are not always so evident

THE refrigerating plant cannot be run intelligently unless instruments are provided. The accompanying diagram of a simple plant shows the necessary thermometers and pressure gages. In addition, there should be a salometer for testing brine density. Other useful instruments include compressor indicator, tachometer, electric meters of various types, water and brine meters, Venturi meters to measure the flow of refrigeration, hydrogen-ion indicator and psychrometer. Whether the set of instruments is to be elaborate or confined only to the essentials, they should be of good quality, graduated closely enough for easy reading, and they should be frequently checked for accuracy.

Before discussing troubles, let us consider the conditions that the operator should strive to obtain. Compressor discharge pressure should be the lowest possible with the quantity and temperature of condensing water available. This is usually about 15 lb. above that corresponding to the outlet water temperature. The suction pressure should be the highest possible to produce the refrigeration effect required without bringing liquid refrigerant back to the compressor. About 5 deg. superheat at the compressor suction is a good operating condition.

The troubles to be considered will presuppose that the plant has at one time operated satisfactorily, and that the difficulty is one of operation rather than design.

High head-pressure may be a perfectly natural seasonal change, because of the warmer cooling water in the summer time. When spray ponds or cooling towers are used, the water should be cooled close to the wet-bulb temperature, and the head pressure can be expected to fluctuate with the temperature and humidity of the atmosphere.

Head pressure may increase because of the accumulation of foul gas. If the temperature corresponding to the head pressure exceeds the temperature of the liquid from the condenser, foul gas is present. To attempt to entirely eliminate foul gas would be wasteful of refrigerant. However, whenever the temperature of the liquid from the condenser is 5 deg. below the temperature corresponding to head pressure, the system should be purged.

With a condenser of liberal size the liquid should be cooled to within 3 to 5 deg. of the outlet water temperature. If the difference is more than this, heat-transfer efficiency has decreased. Loss of heat-transfer efficiency may be caused by scale or slime on the tube surface. It takes only a thin layer of scale to seriously affect operation. Parts of the condenser may not have the proper flow of water. With an atmospheric condenser, the water troughs may need leveling for better distribution. A vertical shell-and-tube type may need adjustment of water swirls, or a multi-pass condenser may be leaking between passes and need a new gasket. Reduction in the quantity of cooling water will also cause an increase in the terminal temperature difference, and may be due to obstructions in the line or worn pump impeller.

Liquid Slop-Over

When liquid comes over into the compressor suction it puts an excessive strain on the machine. The compressor will pound, the safety head may lift, or if there is no safety head, a head may be blown off. In addition, the efficiency of operation is reduced. This condition first of all indicates too much liquid being fed to the evaporator. If a hand expansion valve is used, reduce the feed; with an automatic expansion valve, set for a lower pressure; with a liquid level control, set the float lower, or, if operation had been satisfactory at the set level, open the control and make sure that the valve is not sticking open. If a float expansion is used where all of the liquid is carried in the low side, remove some of the charge.

When a heavy load is thrown on suddenly, causing slugs of liquid to slop over, an efficient accumulator should be installed. The liquid entrapped may be returned to the evaporator by gravity. It may be boiled off by precooling the liquid on its way to the expansion valve, or it may be pumped back to the receiver or the evaporator. Liquid slop-over can be detected by absence of superheat in the suction to the machine, pounding and abnormally cool discharge pipe.

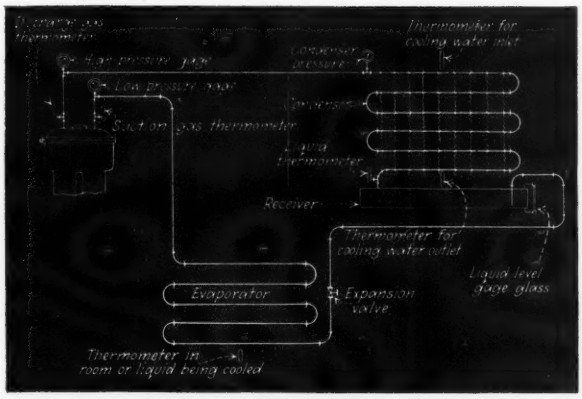
Loss of Capacity

If it has been necessary to lower the suction pressure gradually to get the same temperature, and if at the same time it has been necessary to run the machine longer, or if the former temperatures have been unattainable, the

evaporator is most likely at fault. When room coils are used, the trouble may be caused by an accumulation of frost on the coils. This should be removed, and can be accomplished by letting the room warm up or by admitting hot refrigerant gas from the condenser to the coil.

With water or brine coolers, ice on the evaporator surface may cause the difficulty. When this condition prevails with a brine cooler, the brine most likely needs strengthening. It is best to check this with a salometer, as the brine may already be over the eutectic point, in which case salt crystallizes out and the brine needs weakening instead.

Difficulty in obtaining the desired temperature in refrigerator or cold storage rooms may be due to poor air circulation. The air passages to the bunkers may be



Simple refrigerating plant, showing positions of essential instruments

blocked by goods piled too closely, or by ice accumulation. When forced circulation is used something may be wrong with the fan, reducing the air in circulation.

Loss of capacity in ice plants may be due to poor brine circulation. The agitator may be broken, or a salt bag may be wrapped around the blades. Bulkheads or partitions may be rusted out or torn loose, allowing most of the brine to bypass. In water or brine coolers, a similar condition may exist due to pump trouble.

Oil accumulation on the refrigerant side of the evaporator will also cause loss of capacity. The oil should be drained and cleaned off.

Reduction in capacity may occur with increasing suction pressure. Liquid slop-over will cause it. If, however, the suction gas is coming back at a slight superheat, the trouble will probably be found in a leak from the high-pressure side to the low-pressure side. A bypass valve may not be shut tightly, a relief valve discharging into the low side may be leaking, a compressor valve may not be seating tightly, the rings may be bad, or the cylinder scored. If the trouble is a leaking discharge valve, the compressor will likely run hot.

The difficulty may not be a reduction in capacity of the plant, but an unnoticed increase in load, such as warmer goods going into storage, warmer weather, failure to close doors, or a breakdown in the insulation.

There may be a shortage of refrigerant. Liquid may still show in the receiver gage glass, but the liquid outlet slightly above the bottom of the receiver may be uncovered. When this occurs a hissing sound can be heard at the expansion valve. Liquid in a plant can disappear quite suddenly. As the evaporators become cold they will hold more liquid, so that large amounts may be lying in some of the coils. If possible, more liquid should be charged. Of course, the plant may actually be losing liquid through leaks. With ammonia, which is soluble in water, this loss may be taken up by the cooling water unnoticed. With refrigerants that have no odor, the loss can be direct to the atmosphere.

It is possible for water or brine to get into the refrigerant piping, especially if part of the system operates at a vacuum. This causes a variety of troubles. The water will freeze in the evaporator, clogging it or reducing the heat transfer. If much water is present, large amounts of aqua ammonia will lie in the evaporator greatly reducing the capacity. If slugs of water reach the compressor, severe damage may be done.

To test for the presence of water, draw off samples from all drain valves. Boil the ammonia off by setting the samples in a bucket of warm water. After the sample is warm, and remains warm on removal from the warm water, any unevaporated residue is water or other impurity. If an ammonia generator is available the charge can be purified therein, otherwise the entire charge should be blown out from all parts of the system found to contain water. After the ammonia is all blown away the evaporator should be well blown out with air.

If the compressor-driving belt slaps violently, or if, with direct-connected synchronous motors, the ammeter shows violent flucutations, the trouble is probably due to occasional sticking of the compressor discharge valve.

Occasionally the oil in the crank case of a compressor will become "livery," or some of it will set up hard. To avoid this trouble, use only mineral oils with ammonia, follow the compressor manufacturer's lubrication recommendations, keep oil clean, be sure the compressor crank case is clean and free of rust, do not use paint or other coatings on surfaces in contact with refrigerants, provide efficient scale traps ahead of compressors, and do not let water get into the oil.

Maintenance Safety Rules

- **NEVER break the connections to any part of a refrigerating system until it has been allowed to *warm up* and has been evacuated. Liquid refrigerant will lie in cold coils, even though they have been under a vacuum.**
- **NEVER repack the stuffing box of a compressor until the crankcase has been pumped out and left open to the atmosphere.**
- **NEVER repack a refrigerant valve in service unless it is opened wide. These valves have a seat under the stuffing box which is closed when the valve is wide open.**
- **NEVER test out an old system or additions to an old system with air pressure. Ammonia and air mixed in certain proportions form an explosive mixture.**
- **NEVER start a warm plant, especially if it has a shell-and-tube brine cooler, by suddenly admitting a large quantity of refrigerant. The sudden temperature strains set up may rupture the vessel.**
- **NEVER fill a receiver, cooler, coils or any part of a plant completely with liquid refrigerant and then close off both inlet and outlet valves. If the temperature rises, a serious explosion will occur.**
- **NEVER allow yourself to become careless in handling refrigerants. Almost all of them are irritating, dangerous gases under high pressure.**

Good Housekeeping, And Commonsense Operating Methods

HALVE FUEL BILL

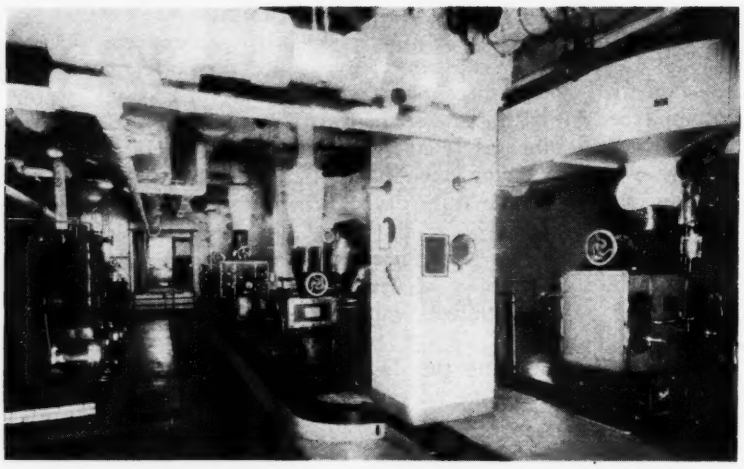


Fig. 1—General view of the Scribner Building engine room

AN EXAMPLE of how greatly the cost of power and heat may be reduced by good housekeeping methods and commonsense operation is to be found in the power plant of the Scribner Press Building in New York City. Since the present engineer took over the operation of this plant in July, 1932, he has cut the fuel bill approximately in half and reduced the quarterly bill for water to one-third of what it had previously been. This was accomplished by change of fuel, stopping leaks and installation of a new engine.

The plant supplies power for lighting, elevator and manufacturing loads, together with heat for domestic hot water, building heating in the winter time and process steam at 60 lb. It contains four boilers operated at 130-lb. steam pressure. Each boiler has 2,590 sq.ft. of heating surface and is hand-fired.

The generating plant consists of one 100-kw., one 200-kw. and two 300-kw. old four-valve engines. A new 300-kw. unaflow engine had been installed, but not placed in operation at the time the present engineer took over the plant. These engines exhaust against 2½-lb. back pressure, supplying steam for heating the building during the winter months and for heating feed water and domestic service.

When the plant was taken over the new engineer found most of the joints in the main steam lines leaking, the glands of many of the valves leaking, and a considerable amount of piping, both used and unused, requiring removal or replacement because of its badly corroded condition. Coal consumption, as indicated in the table, ranged from 216 to 289 tons per month. Water for the power plant was costing about $645 a quarter.

The first change instituted by the new engineer was a change of fuel. The plant had been burning anthracite at about $6.50 a ton. On Aug. 12 the new fuel, consisting of a mixture of half "Bitracite" and half rice anthracite, was instituted. Bitracite is a petroleum coke with a heating value of about 16,500 B.t.u. per lb., and an ash content of about ½ per cent. Introduction of this new fuel not only decreased the coal consumption, but also decreased the amount of ashes that had to be removed. As shown by the table, between 500 and 600 150-lb. cans of ash had been removed per month. With the new fuel this dropped to about 200 cans per month. This reduction in the amount of ash to be removed made the labor available for other work.

The next effort was directed towards the reduction of steam and water consumption. The new unaflow engine was placed in operation and, because of its better efficiency, required less steam to produce the required output. A further saving in steam was secured by repairing all of the leaky pipe joints, repacking valves and repairing steam-driven pumps.

A large waste of steam and water was found in the heating system. It was discovered that all of the heating system returns were simply discharged to the sewer. A vacuum pump was installed which discharged the condensate from the heating system to a feed-water storage tank. This not only saved the heat in the returns, but also decreased the amount of make-up water required. Arrangements were also made to collect and save drips from the engine and steam piping.

Boiler blowdown is discharged to a tank in which are pipe coils through which boiler make-up water is circulated, thus recovering some of the heat in the blowdown. Inspection of these coils disclosed a hole as big as one's finger through which city water was flowing at all times into the blowdown water, and thence to the sewer. This was, of course, repaired, and at the same time the make-up line was decreased from 2½ to ¾ in. These changes and repairs reduced the quarterly bill for city water from $645 to $200, a decrease of 69 per cent.

Reduced steam consumption and higher feed-water temperature made it possible to carry the load with two of the boilers in operation. This permitted changes to be made to the other two boilers. It was found that the height of the bridge wall had gradually increased, until the distance between the tubes and the top of the bridge wall had been reduced to about 6 in. As this narrow passage interfered with the proper flow of gases from the furnace, the bridge wall was lowered until its top was 28 in. below the boiler tubes.

Fuel Consumption and Cost

	1931			1932		
	Fuel Consumption Tons	Dollars	Ash Removed Cans	Fuel Consumption Tons	Dollars	Ash Removed Cans
August	289	1,878.02	615	154	817.81	309
September	216	1,462.17	531	137.5	811.40	219
October	243.8	1,605.15	528	130.8	795.70	197
November	236.9	1,573.41	547	131.8	837.60	195
December	247.2	1,634.06	531	154	872.00	248
	1933					
January	145.8	833.08	240			
February	131.18	775.77	226			

The first baffle in the boiler had been placed on the first row of tubes. This old baffle was removed and a new one installed on the third row of tubes, thus increasing the number of tubes exposed to direct radiation of the fire. It also decreased the area in the second pass of the boiler, thus increasing the flue gas velocity and, therefore, the heat-transfer rate.

Although the boiler had been opened up and cleaned as much as possible, time was not available for turbining the tubes until the latter part of December. This work revealed about $\frac{1}{8}$ in. of scale on the boiler tubes. The reconditioned boilers were placed back in service about the middle of January, and the resultant savings due to

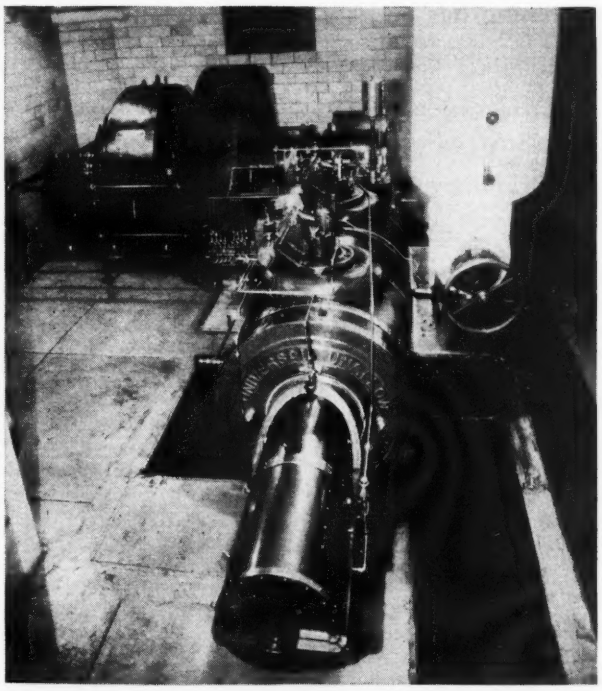


Fig. 2—The new 300-kw. unaflow engine as installed at the far end of the engine room

maintenance are reflected in the reduced coal consumption for February. It was found that one reconditioned boiler would carry the entire plant load.

The average load on the plant is indicated by the curve shown in Fig. 3. The monthly energy output varies but little and averages in the neighborhood of 29,200 kw.-hr.

All of the work done in the plant has been accomplished by the regular operating crew, whereas previous maintenance work had been done by outside contractors. The various changes, including installation of the new engine generator set, cost $30,000, whereas the saving in fuel and water cost alone will apparently amount to about $8,130 a year, returning the investment in less than four years.

The next improvement that the engineer is planning to decrease still further the cost of operating this power plant, is the installation of instruments. The instruments most needed are in the boiler room for measuring the steam output of the boilers, flue gas temperatures and CO_2 and watt-hour meters in the engine room.

The information contained in this article has been secured through the courtesy of H. Cadmus, one of the directors of Charles Scribner's Sons, and John Elsman, chief engineer of the Scribner Press Building.

Research Advances

ELEVATOR SAFETY

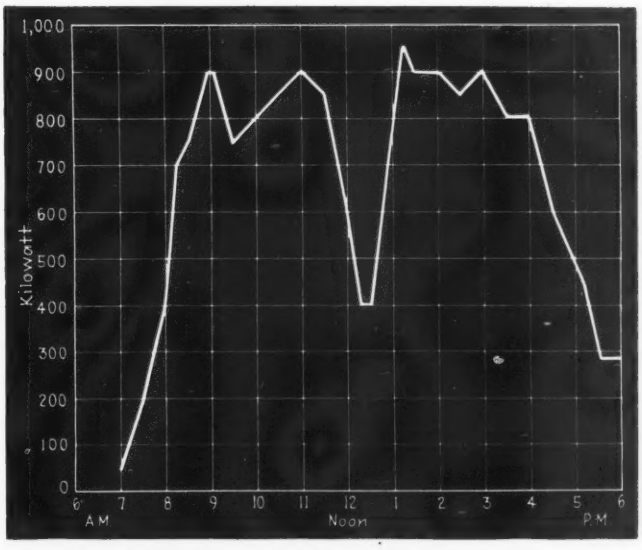
WITH rapid development of high-speed and long-rise elevators required by the tall buildings of today, adequate provision for the safety of passengers has become of paramount importance. Foreseeing this situation, the A.S.M.E. Special Research Committee on Elevator Safeties was organized in 1925. The purpose was to establish well-substantiated design data for safety devices, develop methods of test for the approval of such devices and to recommend needed changes in existing safety codes.

Since that time, the committee has spent nearly $85,000 in experimental work at the National Bureau of Standards and has provided manufacturers with data which they have used in building their safety devices. At the same time the knowledge obtained from this experimental work has been used in interpreting and revising the American Standard Safety Code for Elevators, the last edition of which was published in 1931. This code, which covers the construction, installation, maintenance, and operation of elevators, dumbwaiters and escalators, has been adopted in whole or in part.

Unfortunately, it appears that the experimental program will soon have to be stopped, due to shortage of funds. Owing to the great falling off of business in the building industry, most of the former contributors are not continuing their support at this time, although they consider the work of great value and expect to make further subscriptions when business improves.

Special test instruments developed as the result of the Committee's research program are of general interest and may have wide application in the engineering field. The long-stroke pressure recorder might easily be adapted to give full-length records of pressure within the cylinder of steam engines of moderate speed. The high-speed camera developed might be applied to provide stroboscopic motion pictures of internal-combustion engines and similar equipment. The governor-rope tension recorder might record variations in any cable tension.

Fig. 3—Typical daily load curve, a composite of summer and winter loads



VACUUM PRODUCERS FOR

PRIMING CENTRIFUGAL PUMPS

Because of the widely varying conditions for which centrifugal pumps are now used, priming has become an outstanding operating question. To show how this problem is being solved, *Power* is presenting in this and two succeeding articles the different methods of priming pumps. This article considers the use of vacuum-producing devices separate from the pumps.

POSITIVE-displacement pumps, such as the plunger and some rotary types, if in good condition, are self-priming for total suction lifts up to 28 ft. There are installations, however, because of long suction lines, high suction heads and other abnormal conditions, where positive-displacement pumps must be primed to insure satisfactory operation. Centrifugal pumps are not self priming, and when operated on a suction lift, means must be provided to prime them. In some applications it is also necessary to provide means to keep them primed.

Priming of pumps may be divided into three general classes of installations:

1. Those in which water is admitted to the suction pipe until the air is displaced and the suction pipe and pump are filled with water.
2. Those in which the air is exhausted from the suction pipe and pump with a vacuum pump.
3. Those in which the pump is made self priming by recirculating water in the pump, or by special devices in the suction line.

Priming may be done manually or automatically. Manual priming includes several arrangements. When the pump is located below the suction level, it is primed by opening the petcock on the volute and allowing water to flow into the pump until it begins to come out of the cock.

When the pump is above the suction-well's surface, some means must be provided to fill the pump and suction pipe with water. When this cannot be done from a supply above the pump, the air must be exhausted from the suction pipe and pump so that water will rise from the suction well into them. The first method requires a foot valve to keep the priming water from flowing back into the suction well. A connection may be made from a source of pressure water, such as the city supply, to the suction line. When the pump is to be primed, water is allowed to run into the suction pipe until it begins to flow from the cock on top of the pump casing.

If the foot valve is tight, once the pump is primed it should always remain primed, but dirt lodging in the valve is likely to destroy tightness. Then when the pump is shut down, water will leak out and the suction pipe and the pump will require repriming before starting. Because of air leaking into the suction pipe or gas being liberated from the water, the pump may become air bound and lose its prime when in operation. When this occurs the pump should be shut down and primed in the usual manner.

If the discharge pipe remains full of water, the pump can be primed by a bypass around the check valve in the discharge pipe. This method also requires a foot valve.

On small pumps having short suction lines, requiring priming infrequently, a hand-operated vacuum pump may be connected into the top of the pump casing to exhaust the air.

Ejectors operated by steam, compressed air or pressure water may be used for priming. Fig. 1 shows the cross-section of such an ejector. The ejecting medium is admitted at E and passes out through D. In doing so it draws the air in at S, which is connected to the pump casing as in Fig. 2. To prime the pump, open valve V in the steam or air line, then open valve V_1 in the suction of the ejector. When water starts to flow from the discharge pipe of the exhauster, the pump is primed and the valves may be closed in the exhauster. If the suction line is long in this type of installation, a foot valve should be used.

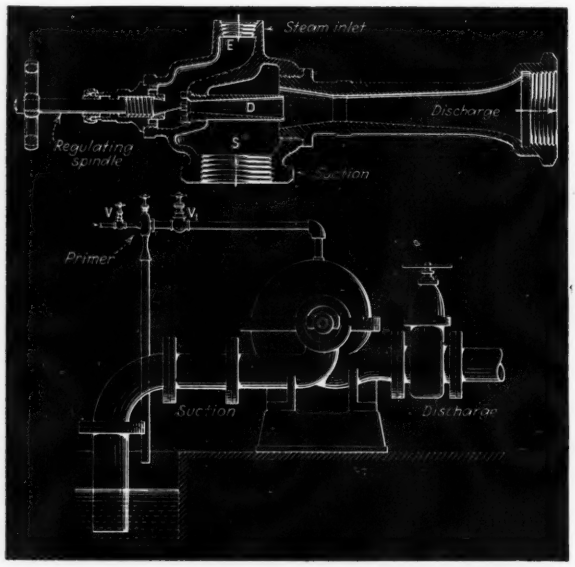


Fig. 1 (Top)—Section through ejector-type pump primer. Fig. 2—Ejector connected to prime a centrifugal pump

Where a source of vacuum, such as a condenser in a power station, is available, it may be connected to the tops of the pump casings and controlled by a valve to prime them.

Vacuum pumps are used extensively to prime centrifugal pumps, either by manual or automatic control.

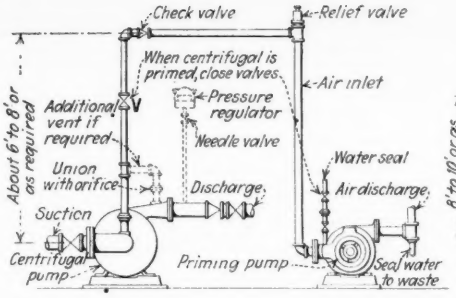


Fig. 3—Vacuum pump connected for manual control of priming.

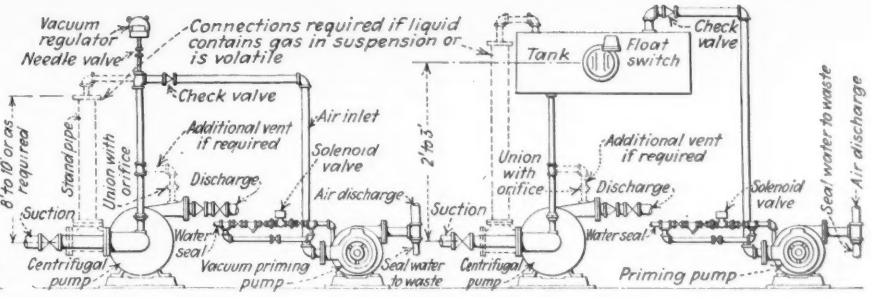


Fig. 5—Vacuum priming pump controlled by float switch

Fig. 4—Vacuum priming pump controlled by vacuum regulator.

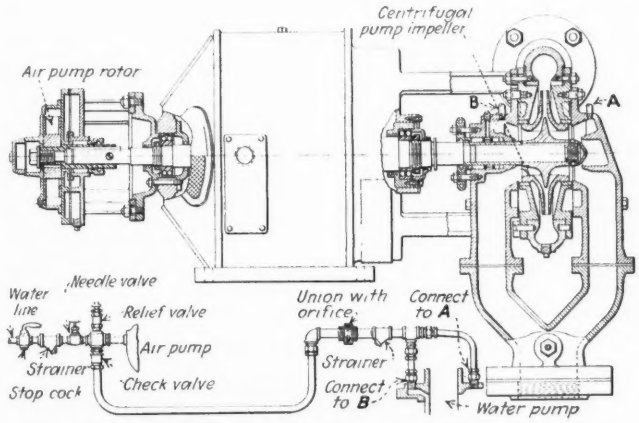


Fig. 6—Priming connections for continuous operation of vacuum pump

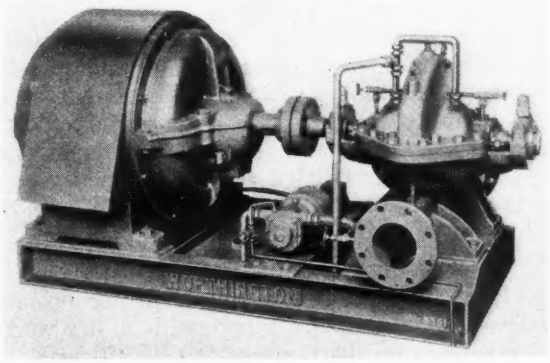


Fig. 7—Vacuum priming pump (center) controlled by pressure switch

Figs. 3 to 5 show arrangements, suggested by the Nash Engineering Company, for priming with a rotary vacuum pump. The full-line layout, Fig. 3, indicates the arrangement for manual control of the primer. When the centrifugal pump is to be primed, the vacuum priming pump is started. After priming, the vacuum pump is shut down and the valves closed in the air and in the water-seal lines.

With the hook-up shown in Fig. 3, a relief valve is provided which will open at a vacuum slightly higher than that actually required to flood the centrifugal pump casing. This relief valve prevents water from coming over into the vacuum pump. Opening of the relief valve is an indication that the centrifugal pump is primed. For conditions requiring continuous operation of the vacuum pump, the arrangement shown in full line in Fig. 3 may be used, except that valve *V* may be omitted.

Where automatic operation of the primer is desired, a pressure regulator may be connected into the discharge line, as indicated by the dotted lines in Fig. 3. This regulator starts the vacuum pump automatically if the main pump loses its prime and stops the priming pump when priming is completed. With automatic operation it is also advantageous to place a solenoid valve in the water-seal line of the vacuum pump, as in Fig. 4. This valve is opened automatically when the priming-pump motor is started and is closed when the motor stops. For automatic operation, the relief valve, Fig. 3, is not necessary, because the vacuum pump is shut down when the centrifugal pump is primed.

In Fig. 4, the hook-up is for automatic operation of the vacuum pump and is quite similar to automatic control by a pressure switch, except that a vacuum switch is installed on the pump suction. When sufficient vacuum has been created to prime the pump, the vacuum regulator stops the vacuum pump and closes the solenoid valve on the seal-water line.

Another system of priming a centrifugal pump automatically is shown in Fig. 5. A reservoir is installed above the centrifugal pump to maintain a static head on the runner intake and to insure that the pump is primed at all times without having the vacuum pump in operation continuously. A float switch shuts the vacuum pump down when the water in the reservoir reaches a predetermined level and starts it when the level falls to a given position.

To obtain a compact unit where priming is to be continuous, the vacuum pump is mounted on an extension of the motor shaft driving the centrifugal pump, Fig. 6. A connection is made from the centrifugal to the vacuum pump which removes the air from the centrifugal pump casing.

In the pipe connection between the two pumps is installed an easily cleaned fine-mesh strainer to prevent solid matter from getting into the vacuum pump. An orifice plate is put in a union to restrict the flow of water to the vacuum pump to that which it can conveniently handle. A relief valve is also provided on this line to limit the vacuum to the proper value and to prevent unnecessary power consumption. The Buffalo Pump Company uses an arrangement similar to that in Fig. 6.

In Fig. 7 is shown an automatic priming system used by the Worthington Pump and Machinery Corporation. In this the Nash vacuum pump (between the motor and pump) is driven by the fractional-horsepower, direct-connected motor directly behind it. Incorporated in the structural-steel baseplate is a reservoir containing the sealing water for the vacuum pump.

The vacuum pump motor is connected across the terminals of the main motor so that in starting this motor, the vacuum pump is automatically started. Automatic control of the vacuum-pump motor is by the switch behind it. When the centrifugal pump is primed and its discharge pressure reaches a predetermined value, the

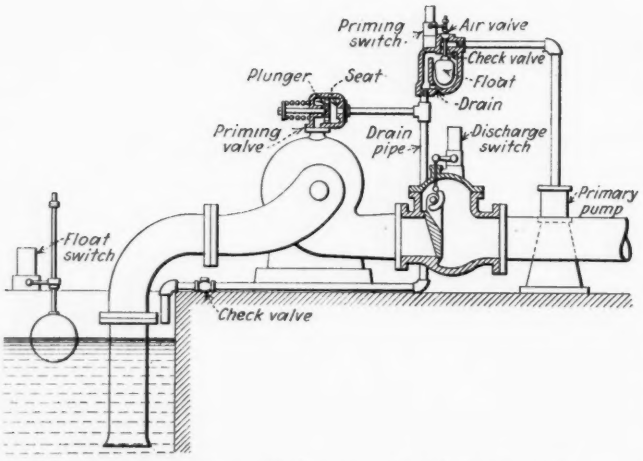


Fig. 8—Float-controlled automatic priming system

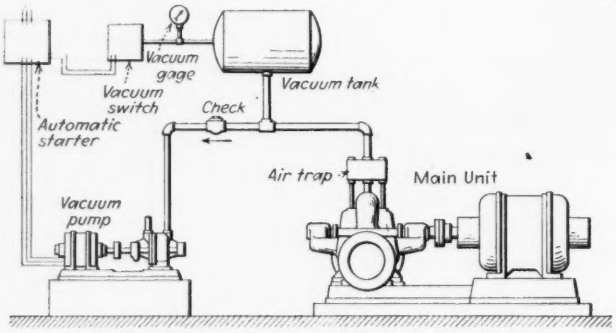


Fig. 9—Vacuum tank serves as a reserve to keep main pump primed

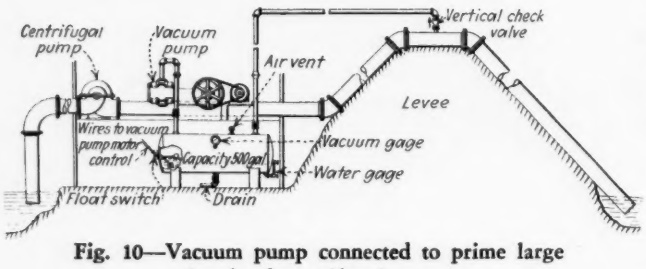


Fig. 10—Vacuum pump connected to prime large low-head centrifugal pump

pressure switch opens and stops the vacuum pump. A check valve between the two pumps prevents air from leaking back into the main pump when the vacuum pump is shut down. If the pump were to lose its prime, the pressure switch would close and start the vacuum pump to reprime the centrifugal pump.

A Barrett Haentjens system of automatically priming centrifugal pumps is shown in Fig. 8. A priming valve is connected between the top of the pump's casing and a float-controlled air valve. The air valve is connected to a priming switch the contacts of which are in series with the control circuit of the main-motor starter. A check valve in the discharge line operates a switch that shunts the priming switch.

As long as the pump is not primed, the priming valve and air valve are in the positions indicated. When the float switch closes, it starts the priming pump, which continues in operation until the main pump is primed and water has come up high enough in the float chamber to close the priming switch. Closing the priming switch starts the main pump, and the priming pump is stopped by a contact that is opened when the pump-motor-control circuit is energized. When the main pump is running, the discharge check valve is held open and the contacts on its switch are closed to complete a holding circuit for the pump-motor contactor, around the priming switch. This switch allows the priming switch to open and not shut down the pump.

A number of small holes in the priming valve plunger permit air to pass freely during the priming operation. These holes are so proportioned that when priming has been completed and the pump started, the pressure developed by the pump forces the plunger to its seat, thereby cutting off communication to the priming pump. When the priming line is sealed, the water drains from the float chamber and the priming switch opens, but the pump-motor contactor is held closed by a circuit through the discharge valve switch. When the float switch opens, it shuts down the main pump. It will be noted that the float switch starts the priming pump when it closes and stops the centrifugal pump when it opens.

The De Laval Steam Turbine Company's automatic-priming system for handling clear water, Fig. 9, includes a motor-driven vacuum pump and a vacuum tank connected between the suction of the vacuum pump and the priming connections on the centrifugal pump. The vacuum tank serves as a reserve on the system so that the vacuum producer need only be started intermittently.

A vacuum switch starts and stops the vacuum producer at predetermined limits of vacuum. An air trap in the line between the pump to be primed and the vacuum tank prevents water from rising into the vacuum system after the pump is primed.

Air is drawn from the pump suction chamber whether the pump is idle or in operation. The priming pipes and air-trap valves are under vacuum to insure that the centrifugal pump remains primed at all times. Modifications of this system are also used for priming pumps handling sewage, paper stock, sludge or other liquids carrying solids in suspension.

Priming Large Low-Head Pump

Fig. 10 is an interesting arrangement for priming a large low-head centrifugal pump with a dry vacuum pump, suggested by the Gardner-Denver Company. In this case the centrifugal pump delivers water over a dike into a river. To insure that the discharge pipe will not become air-bound where it bends over the dike, the whole pipe is primed to that point.

To prime the centrifugal pump, the vacuum pump is started and operated until water begins to flow over into the vacuum tank. The centrifugal pump is then started and the vacuum pump shut down automatically by the float switch opening, after which the tank is drained for the next start. A check valve is placed in the vacuum tank connection near the discharge pipe where it passes over the dike. This check will allow air and water to be drawn from the discharge pipe but will close and prevent air from passing from the tank into the discharge pipe to break the syphon.

In addition to those mentioned in the article as contributing to its preparation, acknowledgment of assistance is also made to J. W. Blakeslee, vice-president of the Blakeslee Manufacturing Company, Penberthy Injector Company, H. G. Conkey, engineer, Ingersoll-Rand Company, and J. Moosbrugger, mechanical engineer, Surban Engineering Company, New York City. The next article will discuss self-priming pumps.

EXAMPLES OF BALANCE IN BYPRODUCT POWER PLANT DESIGN

This article, concluding a series of three, illustrates, by several examples of actual hook-ups, the profound effect of local conditions upon the design of a plant to deliver process steam and byproduct power at lowest over-all cost

By M. K. BRYAN
Chas. T. Main, Inc.
Engineers, Boston, Mass.

THE two preceding articles of the series which this article concludes outlined the principles governing the design of plants to supply process steam and power simultaneously.

The present article will describe, briefly, a few typical installations. The economics of these will not be given, other than to say that all of them are in service and have been operating long enough so that their investment values have been confirmed.

These installations are chosen to illustrate types of applications and to point out some of the physical considerations essential to practical operation and in some cases necessary for best economy. These points will be recognized by following the descriptions.

Non-Condensing Turbine in Parallel with Hydro

The installation outlined by Fig. 1 is a 3,000-kw. non-condensing machine operating in parallel with the hydro-electric units of the property. These units normally generate about 4,200-kw. They are speed governed and the electrical tie holds the speed of the 3,000-kw. steam machine. The proportion of total load carried on the steam machine is controlled by manually setting its governor, so in effect this turbine is a reducing valve between the high-pressure header and the plant steam distribution system.

New boilers were installed to generate steam at 425-lb. pressure and superheat it to 585 deg. This steam condition was superimposed upon the existing plant, using the non-condensing turbine and a reducing valve and desuperheater to lower the steam pressure and adjust the temperature to that required for distribution.

The 120-lb. header pressure and the turbine exhaust pressure are controlled by the reducing valve, which makes up the difference between the factory requirements and the steam passed through the 3,000-kw. machine. The steam exhausted from this machine is superheated about 25 deg. The desuperheater adjusts the quality of steam passed through the reducing valve to the same superheat.

The power load is fairly constant, averaging about 6,000-kw. Use of 120-lb. steam is such as would make byproduct power available in amounts averaging 3,000 to 4,400-kw. throughout the year. The condensing turbines are run only when the hydro output is low.

The annual power consumption in this property is normally about 45,000,000 kw.-hr., 65 per cent being supplied from the mill's hydro-electric plant. Prior to the installation of the 3,000-kw. steam unit about 28 per cent of the power was purchased for a total unit cost of about 8 mills, and the remainder, 7 per cent, was made with the condensing turbines at times of water-power shortage. The normal annual output of the non-condensing unit, about 14,000,000 kw.-hr., replaces all purchased power and part of the condensing steam power.

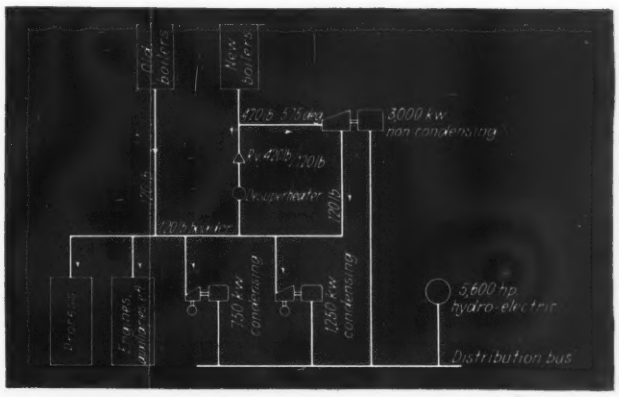


Fig. 1—Non-condensing turbine in parallel with hydro

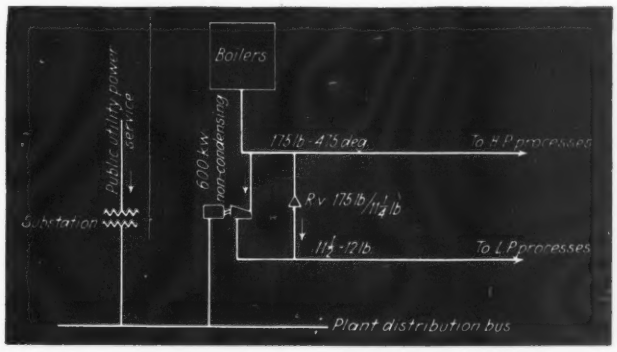


Fig. 2—Parallel operation with utility system

Parallel Operation with Utility System

Fig. 2 shows the installation of a 600-kw. non-condensing turbo-generator which differs from the 3,000-kw. installation just described primarily in the method of governing. This machine operates in parallel with a utility system from which the bulk of power used in the property is taken. Steam at 175-lb. pressure and 100 deg. superheat is admitted to the turbine and is exhausted at 12 lb. pressure.

The speed of the unit is held by the electrical tie with the outside power supply. Power output, determined by the quantity of steam admitted through the throttle, is varied by the demands for exhaust steam, the variations of which cause slight changes of pressure in the exhaust piping. The admission of steam to the turbine is con-

trolled by a back-pressure governor, so-called, which is designed to operate from pressure changes in the exhaust piping, admitting more or less steam to the turbine as the exhaust pressure falls or rises as a result of greater or less use of process steam. A reducing valve by-passes the turbine.

This machine operates without constant attention. The boiler-room engineer takes care of any starting or stopping and keeps the log. Safety appliances are incorporated to protect against: (a) overspeeding; (b) electrical overloading; (c) motorizing by outside current and blade injury due to rotation without steam flow.

In each of the previously mentioned installations the power made by the non-condensing turbine was the smaller proportion of the total power load. Also, each turbine exhausted at only one pressure. The load on the machine first mentioned was controlled by the speed governor setting and that on the second machine by a back-pressure governor.

Bleeder Non-Condensing Turbine Speed Governed

The machine installation represented by Fig. 3 is another non-condensing unit, but one which produces 75 to 85 per cent of the total power and which supplies process steam at two pressures, namely, 120 lb. and 8 lb. This machine is a 2,500-kw. bleeder-type non-condensing unit, operating on speed governor control. A hydro-electric plant operates in parallel with it. Steam conditions at the throttle are 375 lb. pressure and 560 deg. temperature. Steam is bled at 120 lb. pressure for some of the process work and is exhausted at 8 lb. pressure for the remainder of the processes and for space heating.

The amount of steam bled is controlled from the pressure in the 120-lb. piping system by a back-pressure governor. The amount of 8-lb. exhaust is the difference between the throttle steam and the bled steam and since the machine is speed governed the 8-lb. exhaust must vary with the load on the machine. With a varying electrical load, and a process load which varies without any relation to this electrical load, some provision must be made to control the load on the steam unit with relation to the process steam requirements; otherwise there would be considerable waste of steam to the atmosphere at times and at other times considerable steam would be by-passed around the turbine to the processes with a resultant loss of available cheap power.

The power replaced by the steam turbine was that from the company's hydro-electric plant, which was modern and efficient. Water for this plant was supplied from a privately owned canal system under a sliding rate of charging for water used. The charges for water were such that water power on the plant switchboard cost about 8 mills per kw.-hr. Since the privilege to draw water from the canal was granted under a perpetual lease with a minimum annual rental covering the use of enough water to make about 300 kw., no saving was possible by stopping water-power generation completely. Accordingly, the hydro plant was retained, as part of the power supply system, to make a small part, (15 to 25 per cent) of the power and to balance the variations of process demands and the power load changes.

The graphs in Fig. 4 show a day's record of total power load, the steam power produced from process steam and that made by water. Fig. 5 shows the corresponding steam quantities. It is to be noted that the power load is quite variable and that the process steam demands, that is the steam passing the turbine throttle,

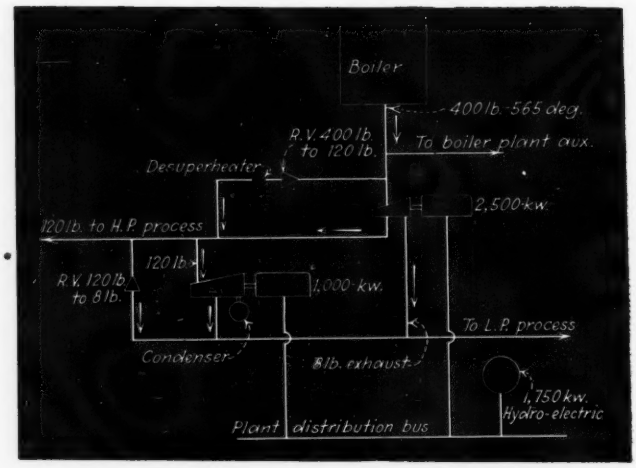


Fig. 3—Bleeder condenser turbine, speed governed

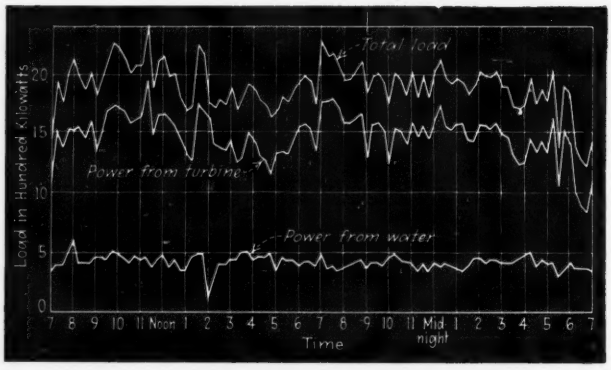

Total load
Power from turbine
Power from water
Load in Hundred Kilowatts
20
15
10
5
0
7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11 Mid night 1 2 3 4 5 6 7
Time

Fig. 4—Day's power-load record of plant shown in Fig. 3

vary considerably and rapidly and without definite relation to the power load.

These changes are accounted for in the system by varying the output of water power. All steam possible is passed through the turbine and such power as can be is made from it. The balance of the power is made by water. The gate opening of the water wheel is varied with a governor responding to changes of pressure in the turbine exhaust piping.

Remembering that the steam turbine is governed by speed and hence will move steam into the process supply piping when the plant load increases, it is apparent that the pressure in the process piping will rise when this occurs, unless the process demands increase correspondingly, and if they do not the steam turbine load must be reduced or else steam will have to be exhausted to the atmosphere. The reverse occurs when the plant load decreases. Accordingly, the pressure changes in the exhaust pipe are transferred to the gate mechanism of the water wheel and the gates opened or closed as the pressure in the 8-lb. exhaust line increases or decreases.

As evidence of the nicety with which this governing and control functions, attention is called to the small difference between total steam generated and that passing through the turbine. This difference represents steam for boiler plant auxiliaries and reducing valves by-passing the turbine. No steam is wasted to the air. The exhaust pressure varies between 7 and 9 pounds. Speed regulation, an important factor in this plant, is much better than when the hydro-electric units were doing the governing.

The 1,000-kw. machine shown in the diagram is an old machine, which is not normally operated. It is of the bleeder condensing type.

In most non-condensing power generator installations some means must be provided to adjust the variations of process steam load and total electrical load if waste to the atmosphere is to be avoided. In the previous illustrations another power source was used for this purpose. This is the usual method of handling the situation. Occasionally the balance is worked out with a heat reservoir, such as an accumulator or a hot water storage, in cases where hot water is used in process work. The installation shown by Fig. 6 illustrates the use of a combination of these means.

Hot Water Used As Heat Storage

The turbo-generator is a 3,000-kw. unit receiving steam at 190-lb. pressure at 500 deg. and exhausting into a condenser at 2-in. vacuum. Steam for process work is extracted at two pressures, 125 lb. and 10 lb. Some processes require considerable hot water at 150 deg. Process steam is used throughout the 24-hour period, the daytime use being considerably more than the night demand.

There is no fixed relation of power demand to process steam or hot water uses. It is, consequently, necessary to supply an increasing power demand when the process steam requirements are falling off or the reverse of this condition.

The first situation reduces the amount of steam extracted from the turbine. The decrease in power produced from this steam must be made up by passing steam through the turbine into the condenser. In the installations of non-condensing machines previously described the reduction in power corresponding to decreased process needs was made up from another power generating source, so the condenser in the present case is analogous in purpose to those other power sources.

It is apparent that the steam flow to the condenser, the flow most wasteful of heat, can be reduced by increasing the extraction flow. The hot-water heater and storage are useful in this connection. The demands for hot water are variable during the day period; during the night period they are practically zero. With this cycle, if the hot-water storage is full in the morning it can be drained during the day and refilled during the night period, thereby transferring some of the demand for 10-lb. steam from the day to the night run, during which times the other uses for 10-lb. steam fall off. The effect is to reduce the amount of steam used through reducing valves during the day run and decrease the amount of condenser waste during the night period.

This can be illustrated by an example using the performance figures of the actual machine as follows:

	Hot Water Storage	No Hot Water Storage
DAY CONDITION		
Electric load, kw	2,250	2,250
125-lb. process steam bled from turbine, lb. per hr	80,000	36,000
Passed through red. valves, lb. per hr	.....	44,000
10-lb. process steam bled from turbine, lb. per hr	51,000	60,000
Taken from hot water tank, lb. per hr	9,000	.....
Steam to condenser, lb. per hr	2,000	3,000
Total steam, lb. per hr	142,000	143,000
NIGHT CONDITION		
Electrical load, kw	750	750
125-lb. process steam bled from turbine, lb. per hr	45,000	45,000
10-lb. process steam bled from turbine, lb. per hr	19,000	10,000
Steam to condenser, lb. per hr	4,000	9,000
Total steam, lb. per hr	68,000	64,000

The applications of by-product power generating equipment shown in this article do not, by any means, illustrate limits of the possibilities of combining cheap steam power generation with industrial heat requirements. It is hoped, however, that these examples have demonstrated the adaptability of equipment to enough different local conditions to bring out one point, namely, there is no "cataloged" arrangement for low power costs.

Fig. 5—Steam loads corresponding to power loads of Fig. 4

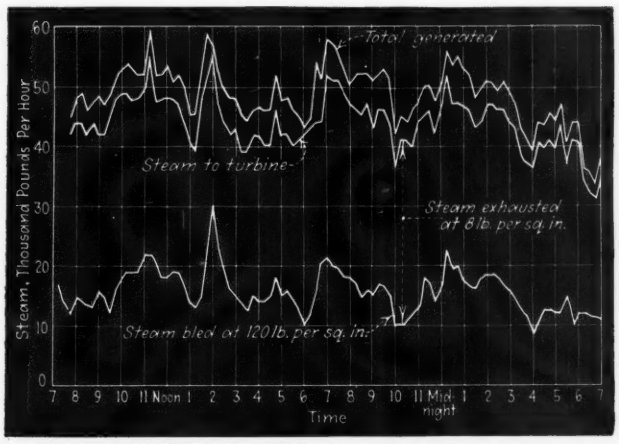
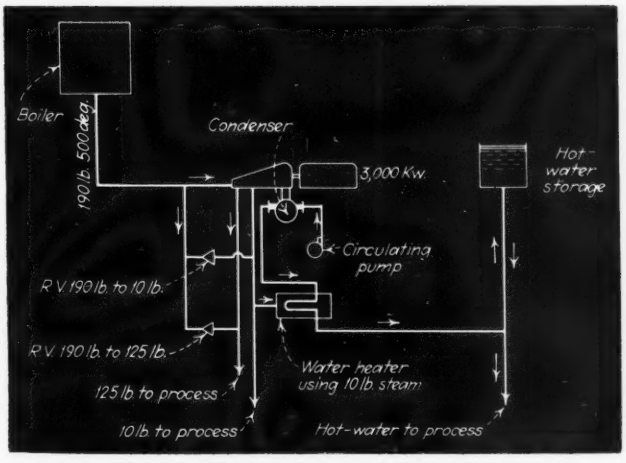

Steam, Thousand Pounds Per Hour
60
50
40
30
20
10
0
Total generated
Steam to turbine
Steam exhausted at 8 lb. per sq. in.
Steam bled at 120 lb. per sq. in.
7 8 9 10 11 Noon 1 2 3 4 5 6 7 8 9 10 11 Mid-night 1 2 3 4 5 6 7
Time

Fig. 6—Hot water used for heat storage



DOES IT PAY TO MODERNIZE?

● *Does it pay to modernize?* An interesting answer to this question is given in estimates released by the Westinghouse Electric & Manufacturing Co. Prepared by Norris D. Gove, turbine engineer, these estimates are based on replacing industrial power equipment built twenty years ago by that of present-day design. By using new boilers and combustion equipment, higher pressure and superheat, modern turbine generator units, bleeder heating, and by retiring other equipment, an average total coal saving of about 50 per cent can be made, according to Mr. Gove.

Mr. Gove's estimates are based on an increase of steam pressure from 150 lb. to 400 lb. gage, and of steam temperature from saturated to 700 deg. total temperature. He also assumes condensing operation with 28-in. vacuum. No mention is made of the much higher savings which may be made in many industrial plants operating non-condensing, where the higher pressure would eliminate steam now wasted to condenser or atmosphere.

CINCINNATI TERMINAL BOILERS ROUNDHOUSE

SWAP HEAT

Heat balance in the boiler plant serving Cincinnati's new rail terminal is improved by utilizing blow-back from direct-steaming locomotives for heating feedwater

CINCINNATI UNION TERMINAL CO. placed in operation this month the new passenger terminal for the use of the seven railroads that serve the city. The station itself, which is on the west side of Cincinnati, is a thoroughly modern structure embodying many unusual features for the comfort and convenience of the traveling public. The whole project, including land, new trackage, station, roundhouse, boiler house, and service buildings, involved an expenditure of approximately 40 millions.

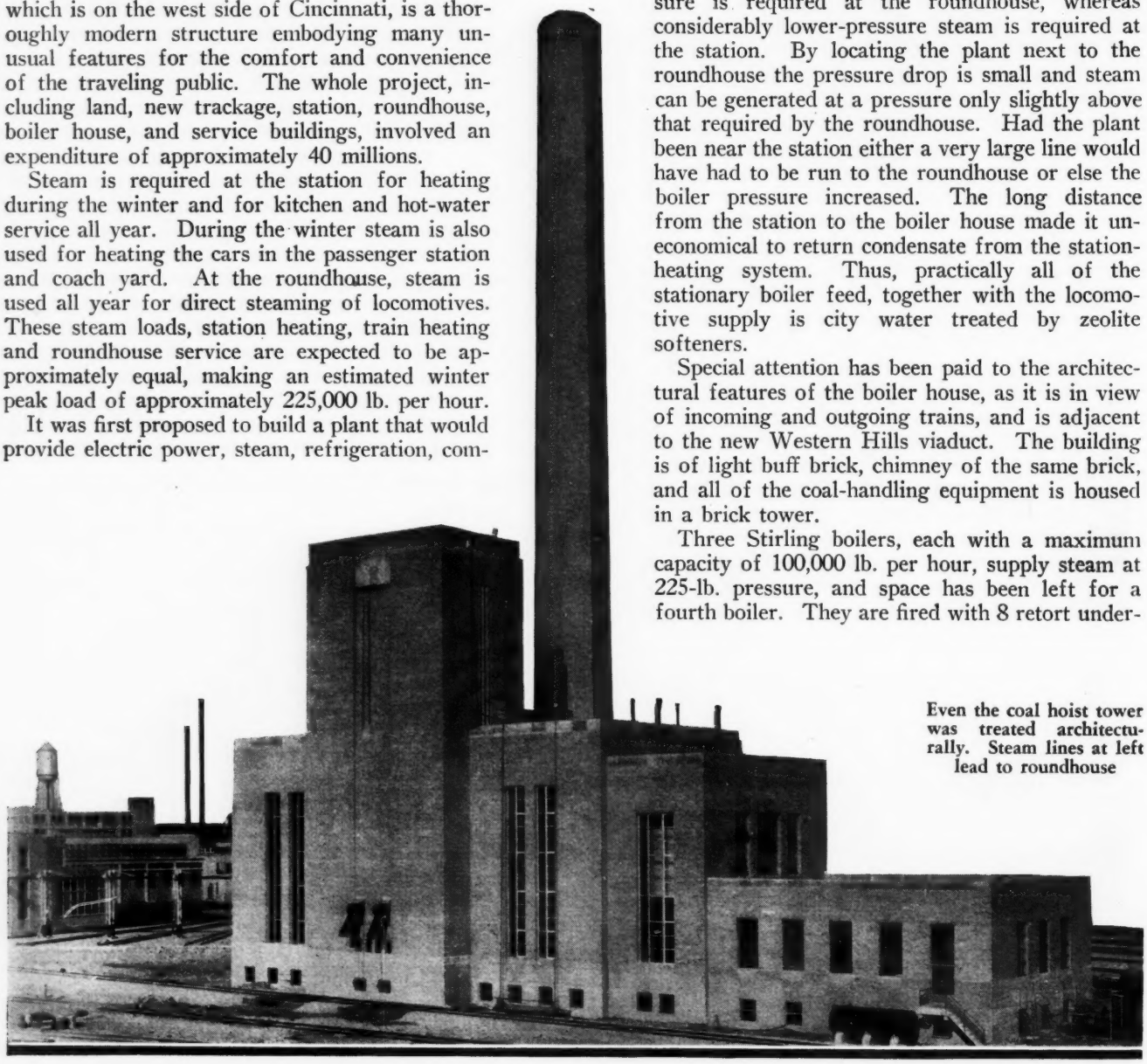
Steam is required at the station for heating during the winter and for kitchen and hot-water service all year. During the winter steam is also used for heating the cars in the passenger station and coach yard. At the roundhouse, steam is used all year for direct steaming of locomotives. These steam loads, station heating, train heating and roundhouse service are expected to be approximately equal, making an estimated winter peak load of approximately 225,000 lb. per hour.

It was first proposed to build a plant that would provide electric power, steam, refrigeration, compressed air and water from the Ohio River for the entire project, and plans for such a plant were fully worked out. Negotiations, however, were concluded for the purchase of electricity, water and ice at considerable advantage to the Terminal Company. Hence the plant built supplies steam and compressed air to the entire terminal, and also includes equipment for supplying locomotives with treated water, wash water and direct steaming while in the roundhouse.

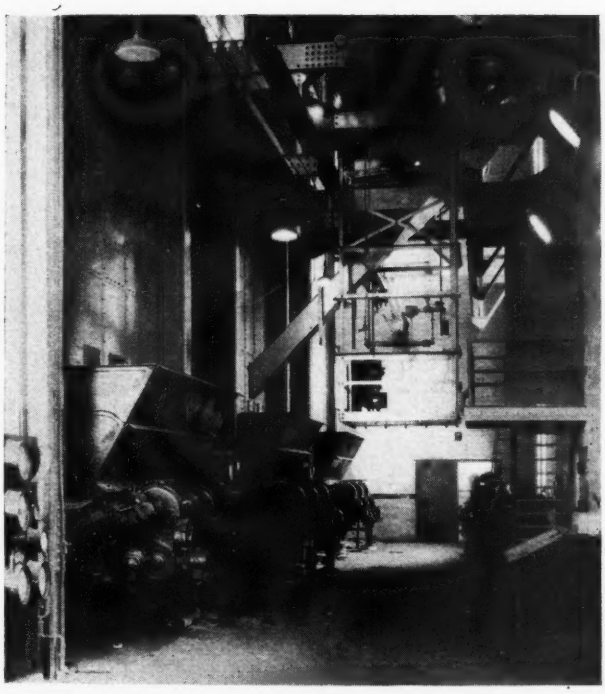
The plant is next to the roundhouse and about 6,000 ft. from the passenger station. This location was dictated because steam at 225-lb. pressure is required at the roundhouse, whereas considerably lower-pressure steam is required at the station. By locating the plant next to the roundhouse the pressure drop is small and steam can be generated at a pressure only slightly above that required by the roundhouse. Had the plant been near the station either a very large line would have had to be run to the roundhouse or else the boiler pressure increased. The long distance from the station to the boiler house made it uneconomical to return condensate from the station-heating system. Thus, practically all of the stationary boiler feed, together with the locomotive supply is city water treated by zeolite softeners.

Special attention has been paid to the architectural features of the boiler house, as it is in view of incoming and outgoing trains, and is adjacent to the new Western Hills viaduct. The building is of light buff brick, chimney of the same brick, and all of the coal-handling equipment is housed in a brick tower.

Three Stirling boilers, each with a maximum capacity of 100,000 lb. per hour, supply steam at 225-lb. pressure, and space has been left for a fourth boiler. They are fired with 8 retort under-



Even the coal hoist tower was treated architecturally. Steam lines at left lead to roundhouse



Both motor and turbine are provided for driving stokers

feed stokers equipped with steam-operated dump grates. The stokers are driven by 7.5-hp. steam turbines, and motor drives are also provided in case the exhaust steam is not required for feed-water heating.

It is expected that slack bituminous coal, sized to pass 1½-in. bar screens, will always be available; therefore no crushers were installed. Coal is taken direct from track hoppers by two 50-ton-per-hr. automatic skip hoists that dump direct through spouts to a 300-ton steel bunker. By means of the two hoists, distribution in the bunker is obtained without a cross conveyor.

The skip hoist is arranged so that once started, it operates automatically until the track hopper is empty or until stopped by push button. As the hoist car comes to the bottom, it opens the gate from the track hopper. When it is filled with coal its increased weight trips an operating mechanism that starts the hoist motor. Thus, the skip is lifted to the top, where it dumps. A time-limit relay, set to give the skip time to dump, then operates to bring the skip down to the track hopper again.

The same hoist is used to store ashes in a concrete bunker between the two hoists. When carrying ashes, however, the hoist is only semi-automatic—that is, the hoist must be manually started for each upward trip with ash—but the skip returns automatically.

Interlocks are provided so that, when handling ashes, the skip cannot descend under the hopper nor can it discharge ash into the coal bunkers. This is accomplished by interlocking a gate on the ash-pit floor with a swing damper in the coal chute. When the bottom gate is open to permit ashes from hand-operated buggies to be dumped into the skip, the swing damper closes off the coal chute and opens the chute to the ash bunker. From the bunker the ashes can be discharged to railroad cars.

Coal is delivered to the stokers from the storage bunker by means of a 2-ton electric weigh larry.

This arrangement of coal-handling facilities is unusually flexible and at the same time easy to operate and low in first cost. Either skip hoist may be shut down for maintenance work without interfering with operation.

The front and side walls of the boilers are air-cooled, but the rear wall is provided with water-cooled wall covered with cast-iron blocks. The entire setting is steel encased.

Cooling air is drawn by an 8,000-c.f.m. fan through four openings in the front wall just above the stoker hopper and three openings near the bottom of each side wall. Air from each half of the front wall joins air coming up through the side walls and passes with it down through a central wall duct to the fan in the basement. Here the turbine-driven, 37,000-c.f.m., forced-draft blower picks up the hot air and discharges it to the stoker wind box. Products of combusion are handled by a single brick chimney 250 ft. high above grate and 14 ft. in internal diameter at the top. Combustion control is provided to regulate under-fire and over-fire pressures in accordance with steam requirements by controlling the boiler outlet dampers, dampers in the outlet of the forced-draft fans and fan speed. The stoker speed is adjusted by hand to maintain desired CO_2.

Instrument boards are provided alongside each boiler and on them are mounted steam-pressure gage, steam flow and CO_2 indicating and recording meters, stack temperature, four-point draft gage and pressure gage for air on the combustion control master.

In addition, a general instrument panel is provided for the distributing line flow meters, pressure and altitude gages, recording thermometers and similar instruments.

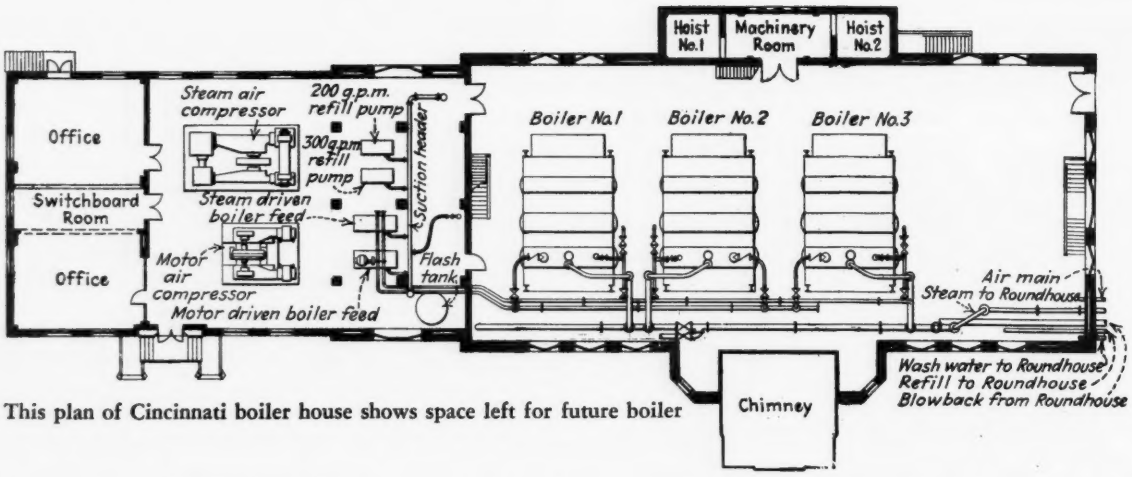
Steam from each boiler is delivered to a single header at the first walkway level in back of the boilers. From the south end of this header the line to the roundhouse is taken on an overhead structure. At the other end, the header drops under the pump-room floor and supplies steam for turbine-driven pumps, the engine-driven air compressor, then leaves the plant to supply the passenger station and other buildings and for car heating.

The direct-steaming system of servicing locomotives is so intimately tied in with the boiler-house heat balance that the former is best described first.

Incoming locomotives have their fires dumped before reaching the roundhouse, then proceed under the steam pressure remaining in the boilers. To decrease the time necessary to start up a locomotive, it is kept hot while in the roundhouse by admitting steam from the boiler house into the lomocotive boilers. Steam condenses in the locomotive and the condensate is blown back to the boiler house about every two hours. Frequently, it will be necessary to change the boiler water completely. When this is done, the entire boiler content is blown back to the boiler house. Wash water and treated fill water are supplied to locomotives from the boiler house.

At the plant the locomotive blow back is received in a flash tank. The flashed steam is condensed in two jet condensers located over two 30,000-gal. hot-water storage tanks. Blow-back water, after passing through a heat exchanger, is stored in a 12,000-gal. tank and is used as locomotive wash water and for quenching stoker refuse. Two pumps are provided for this, a 200-gal. wash water pump and a 100-gal. ash quench pump. The tank and pumps are located in the pump-room basement.

City make-up water is first treated in two 900-g.p.m. zeolite softeners. Part of the treated water is used in the intermediate and after-coolers of the air compressors and then passes through the heat exchanger. City water pressure is sufficient to lift the water from the heat exchanger to the jet condensers, where it is discharged through spray heads.



This plan of Cincinnati boiler house shows space left for future boiler

Cold treated city water is delivered through a level-regulating valve to an outside 300,000-gal. elevated water storage tank, from which locomotive tenders are filled, and also to the jet condensers. It is fed to the condensers under both pressure and temperature control.

Exhaust steam at 1-lb. back pressure from the engine-driven compressor and turbine-driven feed pump is mixed with the flash steam from the blowback water and enters at the ends of the two condensers. The condensate and heated city water flows by gravity to the two 30,000-gal. storage tanks. These two tanks contain silent heaters supplied with exhaust steam from the fan and stoker turbines, to keep the stored water at about 210 deg. The two storage tanks connect to a suction header that supplies two boiler feed pumps each of 400-g.p.m. capacity and two locomotive fill pumps.

The two feed pumps, one turbine driven and one motor driven, discharge to two feed lines. One of these is for emergency use, the other feeds through a boiler water level regulator.

In the pump room are two air compressors, a cross-compound, duplex, steam-driven unit of 1,900-c.f.m. capacity and a 1,460-c.f.m. unit driven by a 300-hp. synchronous motor. These supply air at 125-lb. pressure for electro-pneumatic switch operations and other uses throughout the terminal, of which the principal demand will be for cleaning passenger cars.

While the plant, as built, does not provided for the generation of electricity, it serves as the electrical distributing center for the locomotive terminal area. The 2,300-volt, 3-phase, 60-cycle current is received from the 12,000-volt substations at the service building and passenger station. After passing through outdoor transformers it is fed to the buildings and surrounding area through the combined switchboard in the boiler-house.

Engineering of the entire project has been under the direction of Col. H. M. Waite, chief engineer. Mechanical work has been under the supervision of E. Brock, mechanical engineer, and assistants, A. P. Rasmussen and H. Bartels. Architectural features were supervised by E. D. Tyler, Terminal architect. Information in this article was obtained through their cooperation.

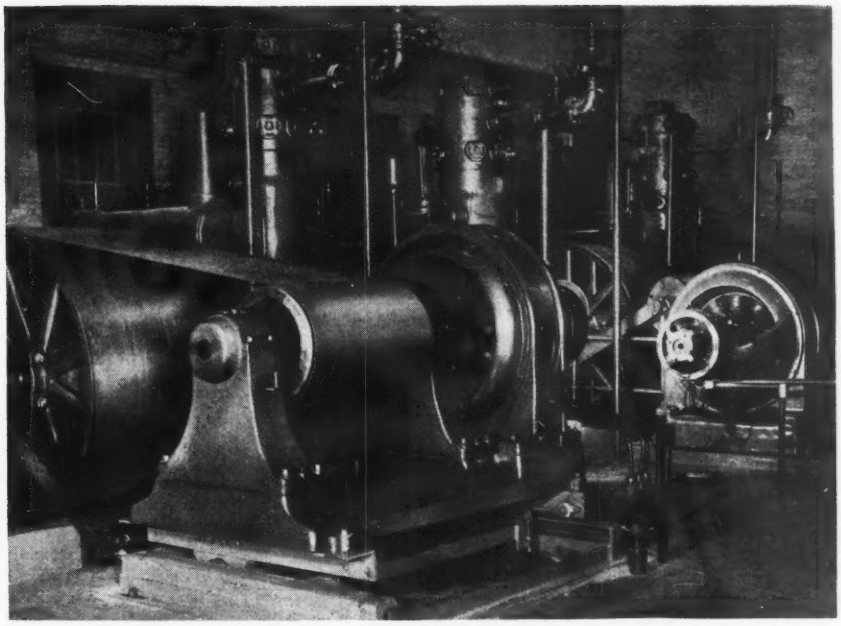
Mechanical and Electrical Equipment

CINCINNATI TERMINAL BOILER HOUSE

Automatic Skip Hoists—two—50 tons per hr. each. Semi-automatic for ash handling, 102 ft. from track to head sheave	C. O. Bartlett & Snow Co.
Track Hoppers—two, 14x18-ft.	C. O. Bartlett & Snow Co.
Steel Coal Bunker, 300-ton	C. O. Bartlett & Snow Co.
Concrete Ash Bunker, 60-ton	C. O. Bartlett & Snow Co.
Ash Buggies	C. O. Bartlett & Snow Co.
Weigh Larry—2 ton	C. O. Bartlett & Snow Co.
Ash Hoppers and Gates (Allen Sherman Hoff Co.)	C. O. Bartlett & Snow Co.
Boilers—3 Stirling type, 10,030-sq.ft. heating surface, 28 tubes 14 ft. long, 3¾ in. dia. 100,000 lb. per hr. maximum steaming capacity, welded drums. 250 lb. per sq.in. working pressure, Bailey rear water wall	Babcock & Wilcox Co.
Settings—air cooled, steel casing	Biglow-Liptack Corp.
Stokers—three, 8-retort, 9,000-lb. coal per hr., 190-sq.ft. of projected grate, motor and turbine drive. Steam-operated dump grates	Westinghouse Elec. Mfg. Co.
Soot Blowers	Diamond Power Specialty Corp.
Blowdown Valves	Yarnall-Waring Co.
Continuous Blow-down System	Cochrane Corp.
Safety Valves—3 per boiler	Consolidated Ashcroft Hancock Co.
Boiler Stop Valves	Edwards Valve & Mfg. Co.
Feed-Water Regulators	Swartwout Co.
Combustion Control	Hagan Corp.
Water Columns	Yarnall-Waring Co.
Forced-Draft Fans—one per boiler, 38,000 c.f.m. at 7-in. pressure, Westinghouse turbine drive, 48.6-hp. 1,950-r.p.m.	Buffalo Forge Co.
Setting Ventilation Fans—one per boiler, 8,000-c.f.m., ½-in. pressure,	Buffalo Forge Co.
Stack, 14-ft. diam., 250 ft. above grate.	Singer Kennedy Co.
Boiler Feed Pumps—two, 400-g.p.m., 310-lb. pressure, one Westinghouse motor drive, one Whiton Machine Co., turbine drive	Goulds Pumps, Inc.
Locomotive Fill-Water Pumps — one 200-g.p.m., one 300-g.p.m., 130 lb. per sq.in., motor drive	Goulds Pumps, Inc.
Wash Water Pump—one 300 g.p.m., 130 lb. per sq.in.	Goulds Pumps, Inc.
Ash Quench Pump—one 100 g.p.m., 60 lb. per sq.in.	Goulds Pumps, Inc.
Condensate pump	Chicago Pump Co.
Heat Exchanger—1,100 sq.ft. of heating surface	Patterson Kelley Co.
Jet Condensers, two	United Boiler & Foundry Co.
Blow-Back flash tank	United Boiler & Foundry Co.
Blow-Back Storage Tank, 12,000 gal.	United Boiler & Foundry Co.
Hot-Water Storage, two 30,000 gal.	United Boiler & Foundry Co.
Water Softeners, Zeolite, 900-g.p.m.	Permutit Co.
Outside Storage Tank, 300,000 gal.	McClintic-Marshall Corp.
Breeching	Lasker Iron Works
Electric Switchboards and Transformers	Westinghouse Electric & Mfg. Co.
Air Compressors—one 2-stage, 1,900-c.f.m., 15½x26x20-in., 180-r.p.m., driven by 395 I.hp. engine, one 1,460-c.f.m., 23x14x16-in., 295-r.p.m.	Ingersoll-Rand Co.
Driven by 300 hp. synchronous motor.	Electric Machinery Co.
Gate valves	Lunkenheimer Co.
Pressure Reducing Valves	Spence Engineering Co.
Heaters—in storage tanks, two	Schutte Koerting Co.
Insulation	Philip Carey Co.
Flow Meters	Republic Flow Meters Co.
Thermometers	The Palmer Co.
CO_2 Recorders	Republic Flow Meters Co.
Draft Gages	Hays Corp.
Pressure Gages	Consolidated Ashcroft Hancock Co.
Ejector	Yeoman Bros. Co.
Back-Pressure valves	Cochrane Corp.
General Contractor	Ferro Concrete Construction Co.

Here are the characteristics and design features that make

FLAT BELT DRIVES



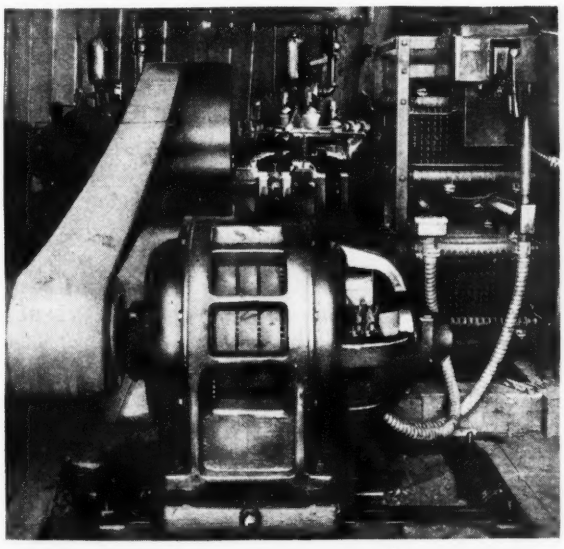
Rockwood drive regulates tension in belt connecting 400-hp. synchronous motor to air compressor. Pulley diameters 24 and 72 in., on 86-in. centers.

Cut Power Transmission Costs

WHEN it can be used, a comparatively high-speed motor connected directly to a machine shaft is generally the preferred type of drive. There are some applications where a direct-connected slow-speed motor is most economical, all things considered, but these may be considered special. For a very large percentage of applications, with medium- or slow-speed drive shafts, a comparatively high-speed motor and some form of speed reducer will be most satisfactory.

Flat belts are one of the oldest devices used for power transmission, and still hold an important place in this field. They may be classed as the simplest of power-transmission mediums and are readily available at hardware and mill supply houses. Their cost is comparatively low and they may be installed to meet almost any drive conditions.

Wound-rotor induction motor arranged so that it can be connected by belt to either of two plunger pumps.



Belt drives are adapted to high- or slow-speed applications. They are readily used for peripheral speeds up to 5,000 to 6,000 ft per min. and have been operated at 10,000 ft. per min. The higher its speed the greater power a belt will transmit up to about 5,000 ft. per min.; beyond this speed the gain in horsepower is not large.

Belts are readily adapted to changed conditions. Their length can be easily increased or decreased to meet the requirements of a change in the drive. They can be operated on long- or on short-centers. Long-center drives with the slack side of the belt on top are usually considered most desirable.

Modern short-center drives are designed to be quite as satisfactory as those that have long distances between pulleys. This has been accomplished by using special belt-tightening devices, by special tanning and treating of the leather, or by a combination of these two methods. Short-center belt drives are being operated on pulley ratios up to 10 to 1, although ratios above 7 to 1 are not recommended.

A belt's ability to absorb shock is frequently in its favor. There is no metallic connection between the load and the motor, consequently shock and vibration cannot be transmitted from one to the other. The belt will temporarily stretch enough to absorb ordinary load shocks. In case of severe overloads or jamming of machinery, a belt will slip and run off the pulleys, thus acting as a protection to driven machine and motor.

An advantage of a belt, or mechanical power-transmission device, is that it practically eliminates the restrictions that are placed on the relation of motor speed to driven-shaft speed by direct drive. Direct-current motors can be designed for almost any practical speed, but the speed of alternating-current motors is confined to definite

values by the frequency of the power system, as indicated in the table. A direct driven machine must be designed to accommodate the motor's speed.

Slow-speed motors have a lower efficiency than high-speed types. Where alternating-current motors are used, the low-power factor of slow-speed induction types may be of greater importance than their lower efficiency. Power companies' rates generally increase as the power factor of the load decreases below a given value. Under these rates slow-speed induction motors, because of their low power factor, are expensive to operate.

The curves show the full-load and half-load efficiencies and power factors of a line of 60-cycle induction motors. Although the deficiency between full-load and half-load efficiency amounts to a maximum of only about 3 per cent, the maximum difference in power factor is over 28 per cent. The half-load power factor decreases much more rapidly as the speed is decreased than does the full-load power factor. Since motors frequently operate more closely to half load than full load, the half-load power factor is of greater importance than the full-load value. At half load the 1,800-r.p.m. motor has a power factor of 0.78, while the power factor of the 450-r.p.m. motor is

Synchronous Speed of A.-C. Motors

R.P.M. 60 Cycles	R.P.M. 25 Cycles	Number of Poles		R.P.M. 25 Cycles	R.P.M. 60 Cycles
3,600	1,500	2	12	250	600
1,800	750	4	14	214.3	514.3
1,200	500	6	16	187.5	450
900	375	8	18	166.7	400
720	300	10	20	150	360

about 0.38, a value that could scarcely be justified on any system.

An 1,800-r.p.m. motor with a good belt drive will cost less than a 450-r.p.m. machine to be directly connected to its machine and will have a higher efficiency if properly installed and maintained. In addition the large decrease in power costs due to the better power factor of the high-speed motor will be a clear gain in favor of this machine.

The high-speed motor of any type has smaller dimensions and is lighter in weight than a slow-speed machine. Because of this the cost of installation and maintenance is usually lower for the high-speed motor with its belt than for the direct-connected slow-speed motor.

If the belt-drive motor fails, it can generally be replaced more readily with a spare than when the machine is directly connected. This feature is frequently overlooked. Any motor of sufficient capacity to drive the load that is suited to the power supply usually can be readily adapted to a belted drive, temporarily in an emergency. This is not true of a direct-connected motor, or when the motor is built into the driven machine.

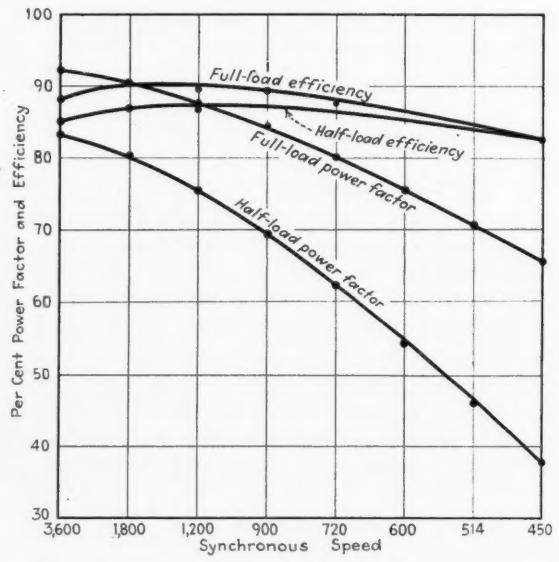
Belt drives, like any other mechanical power-transmission equipment, must have ample capacity for the load they drive. If a belt does not have sufficient capacity, it must be operated with excessive tension, which reduces its efficiency and life, and causes undue wear of equipment parts. In addition, the drive may give unsatisfactory service and have a high maintenance cost.

A belt that is good for a 25-hp. load is not necessarily suited to connecting a 25-hp. motor to its load. The character of the load and the type of motor must be considered. For example, a belt to connect a motor to a fan need have no greater capacity than the motor. On the other hand, a wound-rotor motor connected to a coal or a crushed-stone conveyor that may have to be started fully loaded during cold weather will require a belt with considerable more capacity than normal motor rating.

A wound-rotor motor can develop up to over 300 per cent. of rated full-load torque at starting. If starting conditions are severe, then sufficient capacity must be provided in the belt or it will be unduly overloaded, and may even fail to start the load, slip, and come off the pulleys. These conditions have not been as generally recognized in the selection of belts as they should be. Because of this, belt drives have given poor service that would have been satisfactory had proper attention been taken of load characteristics when the drive was selected. On some types of power-transmission equipment up to 150 per cent increase in capacity is made to take care of abnormal conditions of some loads.

During recent years across-the-line start alternating-current motors have come into wide use. Some of these types develop a high starting torque which is applied to the load suddenly. Unless the belt is selected with sufficient capacity to take care of these conditions, trouble is likely.

The distance between pulley centers has an influence on the capacity of a belt, particularly if the speed-change ratio is high. Not only is a belt that operates on long centers in contact with a greater arc of the small pulley,



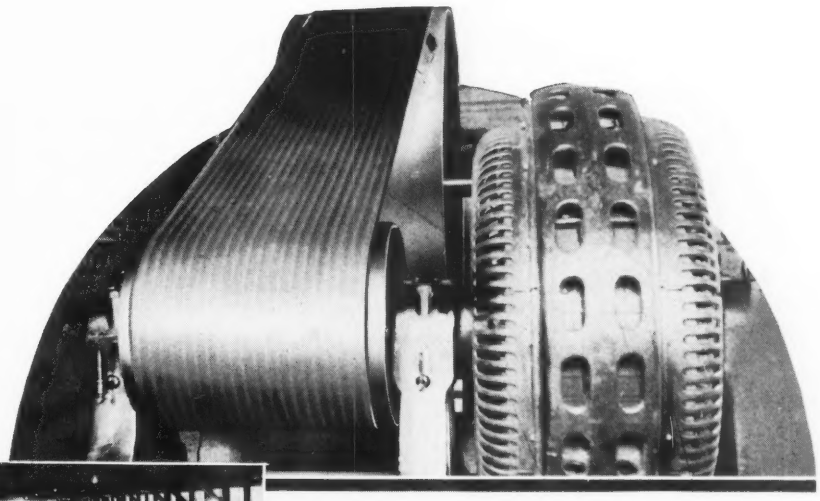
Full-load and half-load efficiency and power-factor curves for a line of 15-hp., 60-cycle, squirrel-cage induction motors.

but it has a greater stretch than a short belt. If the slack side of the belt is on top the sag will increase the contact arc on the small pulley. For short-center belts operating open it is a good rule to increase the width of the belt in proportion to the decrease in arc of contact on the smaller pulley below 180 deg. If the arc of contact is reduced 20 per cent below 180 deg. then increase the width of the belt 20 per cent.

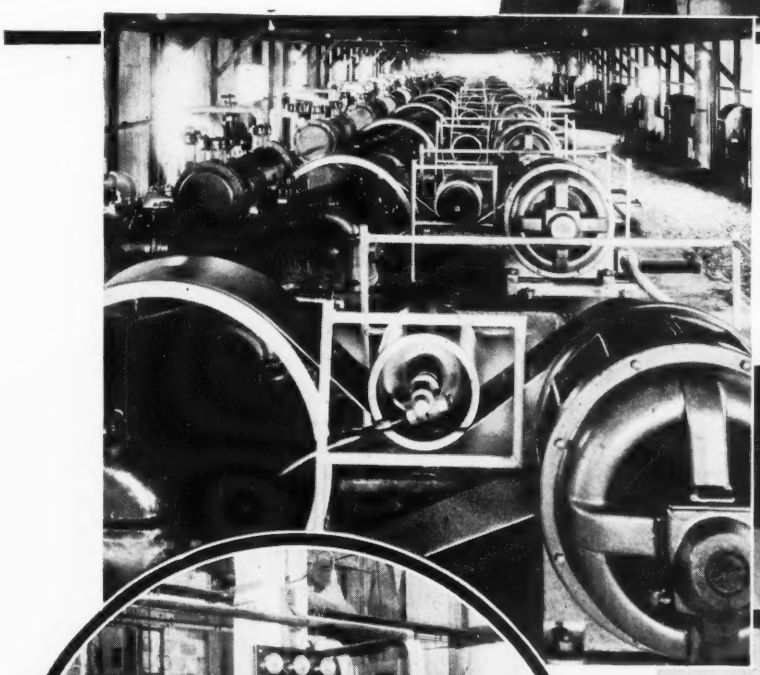
Atmospheric conditions also influence the selection of a belt drive and should be taken into proper account. These conditions not only affect the capacity of the belt but also determine the quality that should be selected. If the atmospheric conditions are abnormal, the belt manufacturer should be consulted to insure obtaining the best quality belts for the service and the proper treatment of the belt after it is installed.

HIGHWAYS for HORSEPOWER

FLAT BELTS LINK POWER SERVICE UNITS

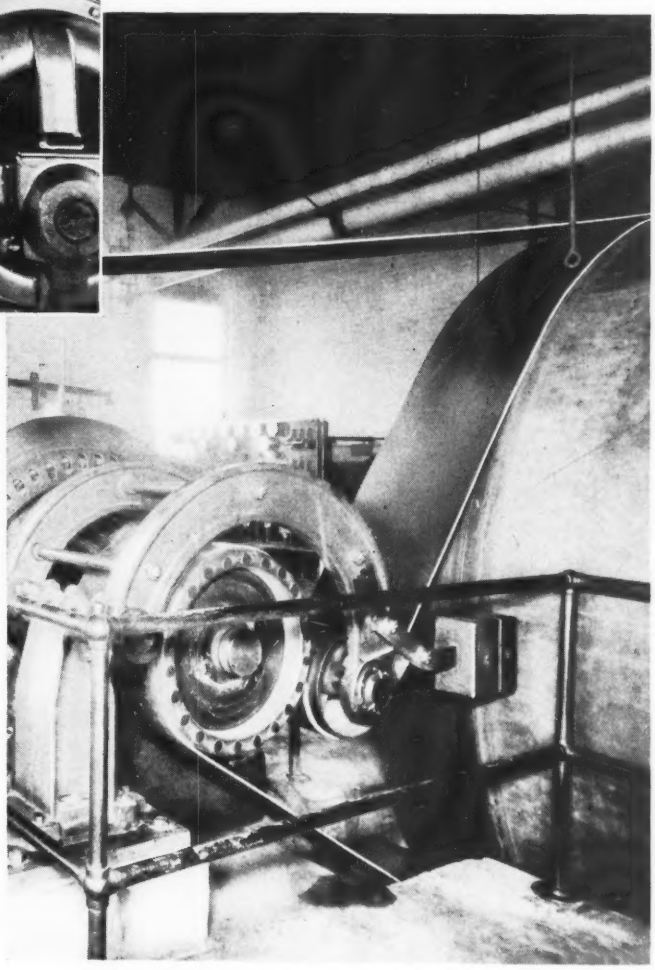


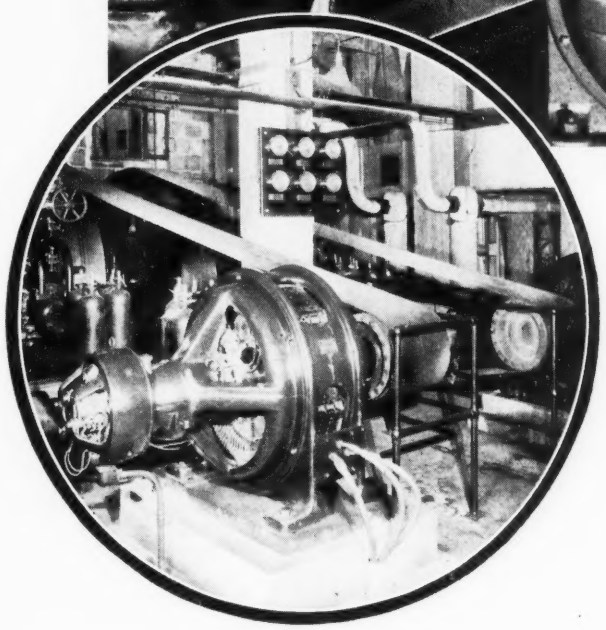
● 400-HP. induction motor connected to fan by Balata Tentacular belt. Pulley diameters 30 and 96 in., on 130-in. centers



● TWENTY-FOUR 75-hp. induction motors connected by belts to air compressors used on air-lift pump wells

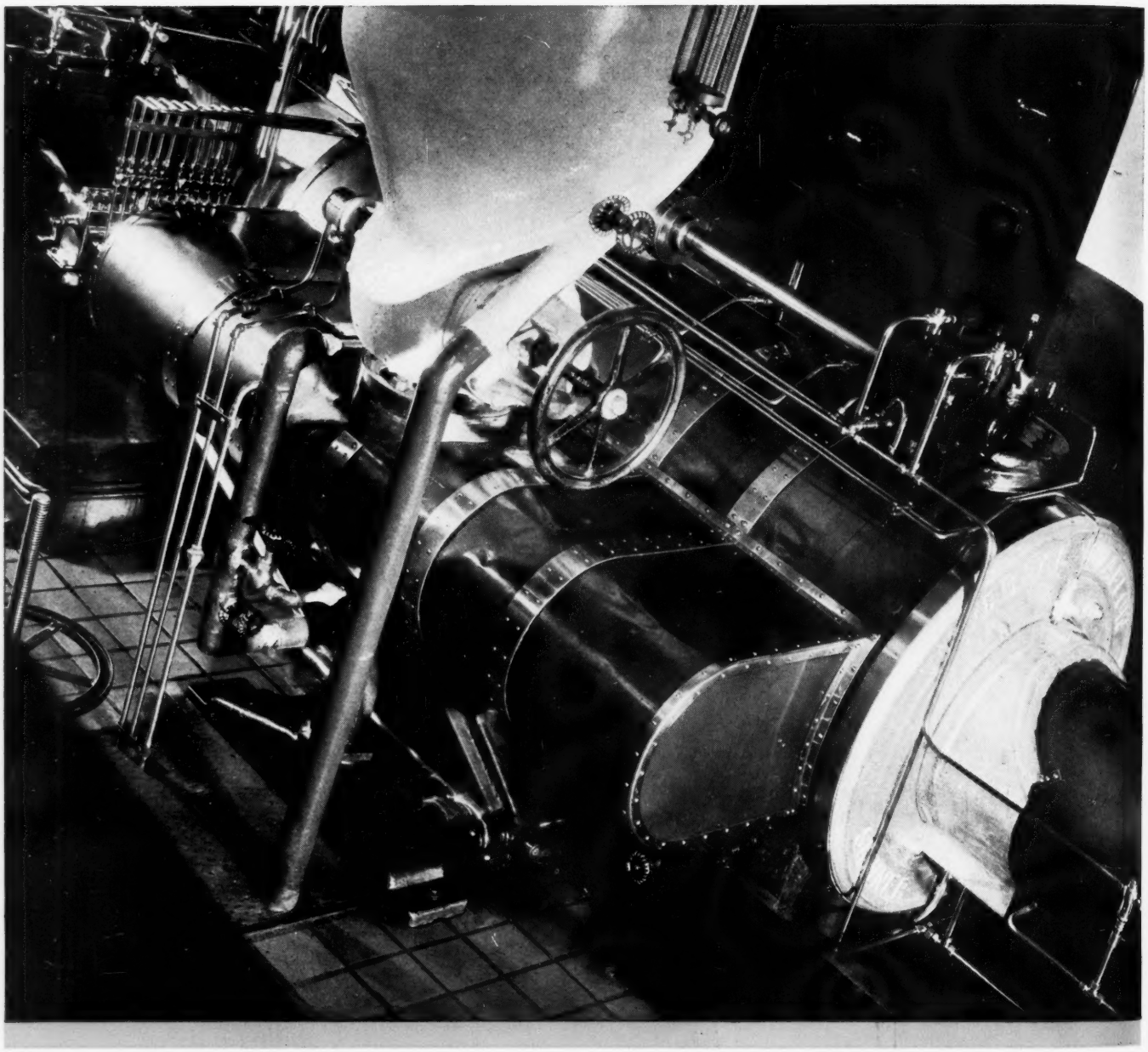
● ALTERNATING - CURRENT generator connected to engine flywheel by Lenix belt drive





● TWO 150-HP., 720-r.p.m. synchronous motors connected by belts to single-cylinder, double-acting CO_2 compressors

Your steam cylinder 100% PENNSYLVANIA



Tycol Steam Cylinder Oils Give You

1 100% selected Pennsylvania crude. 2 Highest flash point. 3 Flattest viscosity temperature curve. 4 Greatest resistance to breakdown due to heat. 5 Absence of cracked material.

oil . . . *is it made from* CRUDE? *Tycol is!*

That's why it has maximum stability . . . shows flattest temperature viscosity curve . . . gives you greatest lubricating economy

CORRECT viscosity . . . chemical and physical stability . . . effective lubrication and sealing films with small consumption . . . these three qualities are of paramount importance in steam cylinder oils. Tide Water's success in satisfying these demands originates with the use of 100% selected Pennsylvania crude which is then refined at low temperatures in vacuum stills to insure the absence of cracked material. In the compounded Tide Water Steam Cylinder Oils, only the highest quality fatty oils are used.

The net result of this strict adherence to quality in raw materials and scientific processing is an extremely efficient group of oils. They have the highest flash point (non-volatile) and the greatest resistance to breakdown due to heat. And it is a well-known fact that Tide Water Steam Cylinder Oils have the flattest viscosity temperature curve, thus assuring adequate viscosity and efficient lubrication, over a wide range of temperatures.

Moreover, the range of Tycol Steam Cylinder Oils is very complete. Tide Water has provided the proper compounding to obtain the qualities for every operating condition encountered in modern reciprocating engine practice. That's another reason why engineers the world over prefer Tycol and profit through the dependable and economical lubrication which these oils assure.

Take full advantage of Tide Water's lubricating engineering service. Have an expert call to make a thorough study of your operating conditions. He will recommend the proper grade of Tycol Steam Cylinder Oil to assure the greatest lubricating economy. This service is yours for the asking.

TIDE WATER OIL SALES CORPORATION
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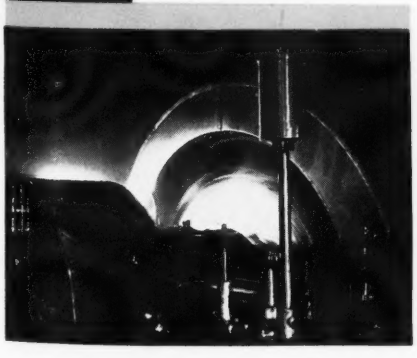


Tide Water combines a complete line of quality lubricants with a specialized engineering service to assure each industry the exact grade of oil or grease for every operating condition.

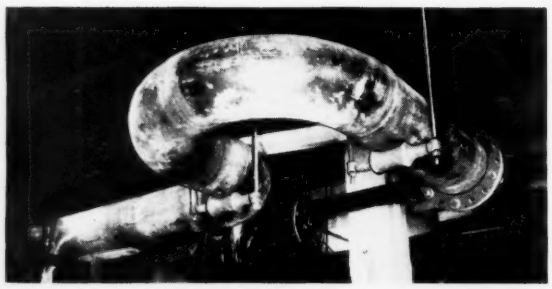
INDUSTRIAL TYCOL OILS-GREASES
TIDE WATER

TIDE WATER *Lubricants and Fuels*
Compressor Oils . . . Hydraulic Turbine Oils . . . Steam Cylinder Oils . . . Transformer Oils . . . Cutting Oils . . . Textile Oils . . . Fuel Oils . . . Gear Greases . . . Ball and Roller Bearing Greases . . . High Pressure Greases . . . Roll Neck Greases.

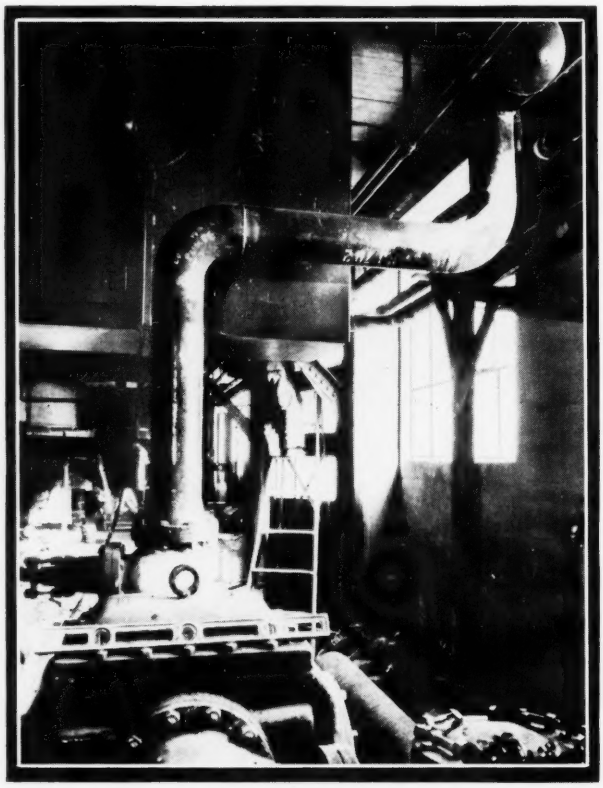
WELDING SMOOTHES

• FROM the few basic types of welded joints, engineers have built up an infinite variety of strange shapes to meet unusual power re-

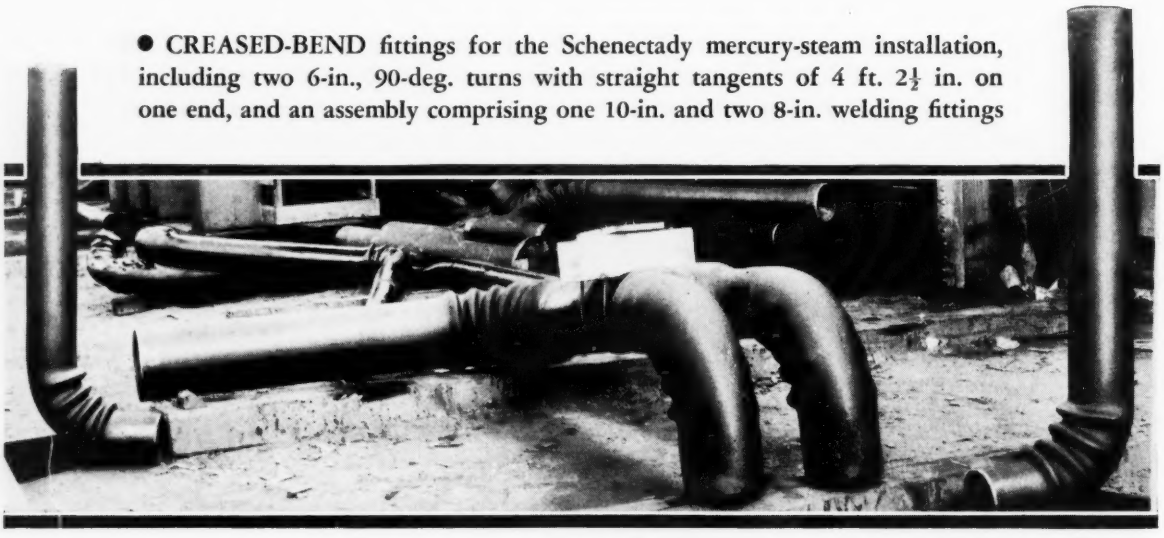
• A 10-IN., 90-deg. creased-bend welding fitting with one end swaged to 8 in. Welded to it is a 6-in., 89½-deg. fitting, one tangent of which has a 28-deg. plain bend



• AN OFFSET turn in a 12-in. oxy-acetylene welded steam main



• PIPING connecting header and steam pump, oxy-acetylene welded

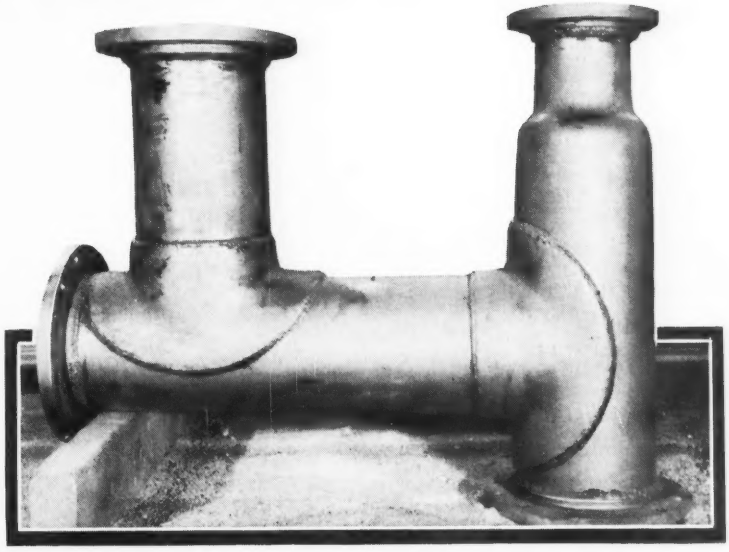


• CREASED-BEND fittings for the Schenectady mercury-steam installation, including two 6-in., 90-deg. turns with straight tangents of 4 ft. 2½ in. on one end, and an assembly comprising one 10-in. and two 8-in. welding fittings

FLUID HIGHWAYS

quirements. Examples here shown include four for the new mercury-steam plant at Schenectady, N. Y. The others are gas-welded joints

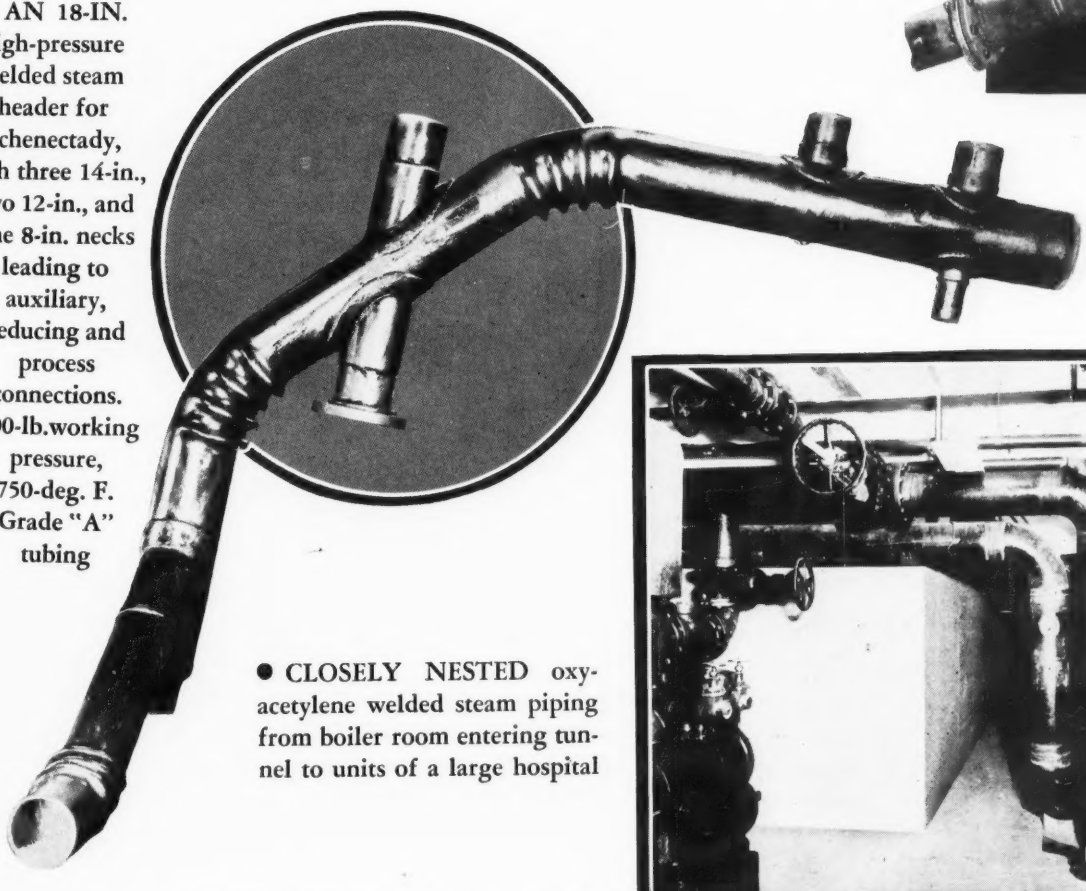
● BRANCH connection welded flush with bottom of steam main to drain main



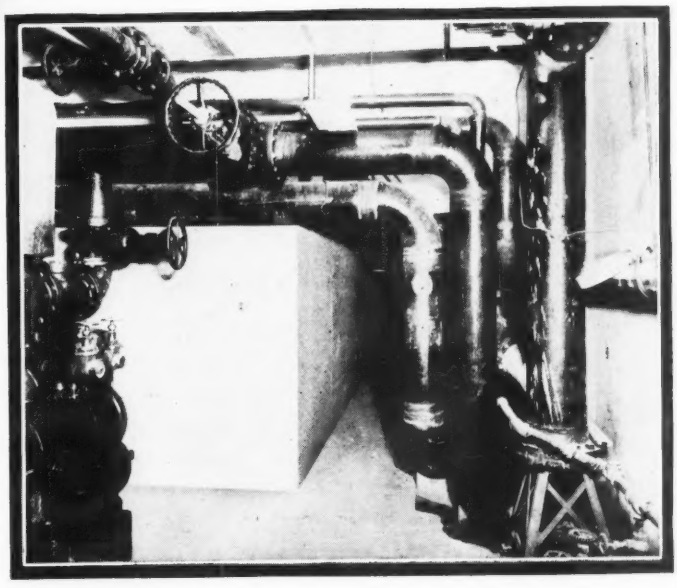
● A BUILT-UP section for Schenectady, 12x8x-12x12-in., 4 ft. 1 in. long from end to end, 3 ft. 9¼ in. high and with welded flanges and saddles

● OFFSET reducer welded into steam main to permit proper drainage

● AN 18-IN. high-pressure welded steam header for Schenectady, with three 14-in., two 12-in., and one 8-in. necks leading to auxiliary, reducing and process connections. 400-lb.working pressure, 750-deg. F. Grade "A" tubing

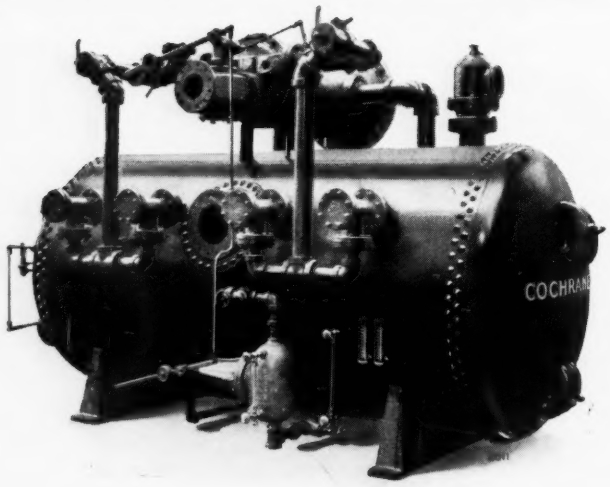


● CLOSELY NESTED oxy-acetylene welded steam piping from boiler room entering tunnel to units of a large hospital



Photographs of Schenectady installation courtesy Pittsburgh Piping & Equipment Co., others Linde Air Products Co.

COCHRANE WATER



For Any Steam Pressure

Cochrane Deaerating heaters can be operated under any steam pressure or vacuum, or with the pressure varying according to momentary load and heat balance conditions. The photograph shows a 250,000 lb. per hr. Deaerating Heater, of riveted plate construction, designed to use steam extracted from the main turbine at a pressure of 150 lb. per sq. in.

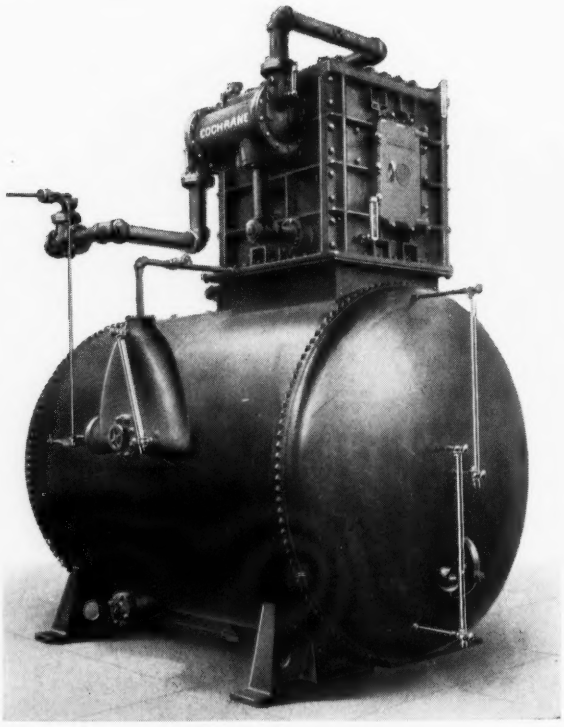
The water is always heated to the temperature of the steam supplied, that is, without terminal difference, thereby improving the efficiency of the heat cycle, as well as expelling all oxygen from solution.

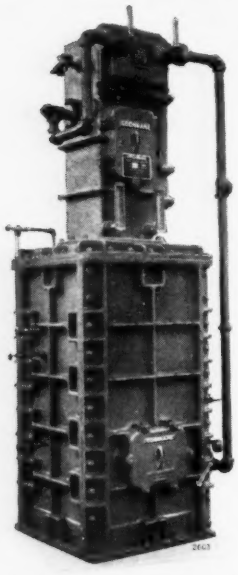
Other things being equal, operation at atmospheric pressure or above is to be preferred, since no air pump or ejector is then required to withdraw the vented gases.

For Storage

A Cochrane Deaerating Heater with suitable storage capacity performs the functions of a surge tank in the feed water circuit, taking up or supplying variations due to fluctuations of boiler contents with load. The deaerated water is held safe from oxygen contamination and in a heated condition, ready to be returned to the operating cycle as required.

Heaters of this type are also used to heat and store water for use in industrial processes as well as for boiler feeding. The photograph shows a heater of 150,000 lb. per hr. capacity mounted on a 600 cu. ft. tank and designed to be operated at atmospheric pressure.





For Buildings and Institutions

Oxygen corrosion of steel and iron piping carrying hot service water, as well as of economizers, boilers and apparatus receiving steam therefrom, is entirely prevented by the use of COCHRANE DEAERATING HEATERS.

In many plants Cochrane Deaerators, either of the surface heater type or of the direct contact type, take the place of the conventional hot water generator, or storage heater, while in others Cochrane Deaerators are employed to prevent corrosion of condensate return lines and of boilers.

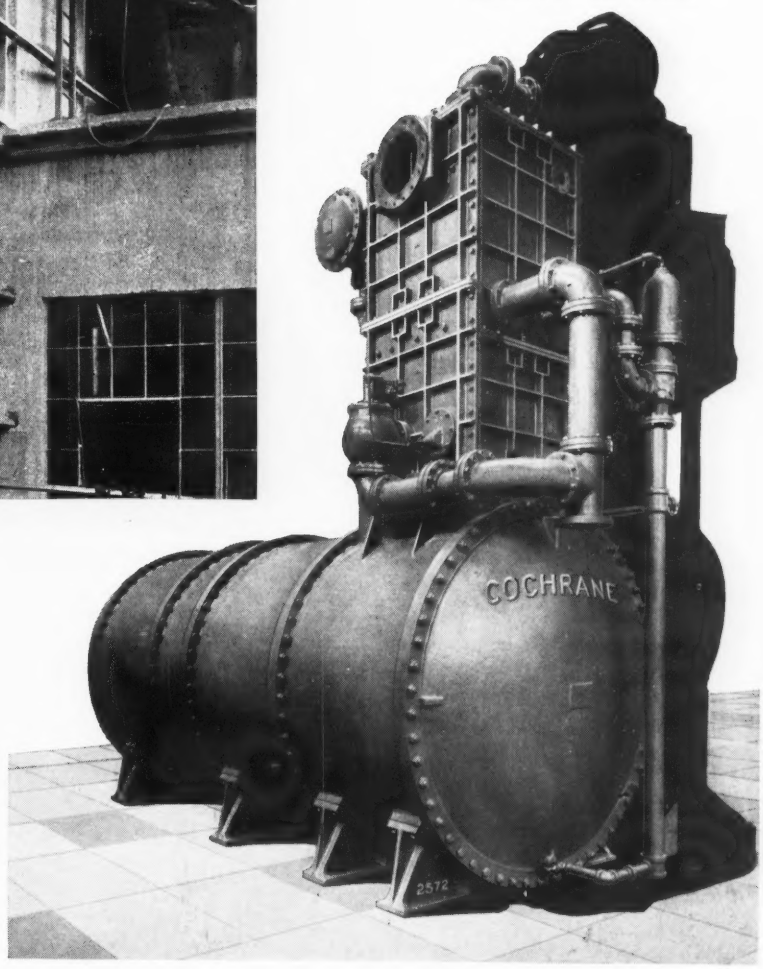
The deaerator shown in the photograph heats and deaerates 22,500 lb. per hr. of heating system returns and of drips from lifting traps in a state institution.

COCHRANE CORP. 17th & Clearfield Streets, PHILADELPHIA, PA.

R CONDITIONERS

32,000 gal. per hr. Cochrane Hot Process Softener treating make-up for 400 lb. boilers at Pennsylvania Sugar Company's plant, which is also equipped with Cochrane Continuous Blow-Off System, Cochrane Filters for removing oil from condensate, and Cochrane Multiport Back-pressure Valve

120,000 lb. per hr. Deaerating Heater, with storage tank, for a state hospital; Machined joint, cast-iron construction.



For Preventing Scale and Corrosion

What treatment is best for boiler feed water depends upon the nature of the raw water, the size of the boilers, the steam pressure carried, the nature of the load and the character of the operating personnel.

For boilers of medium and large size using such water supplies as are generally available, the Cochrane Hot Process Softener has demonstrated unequalled advantages.

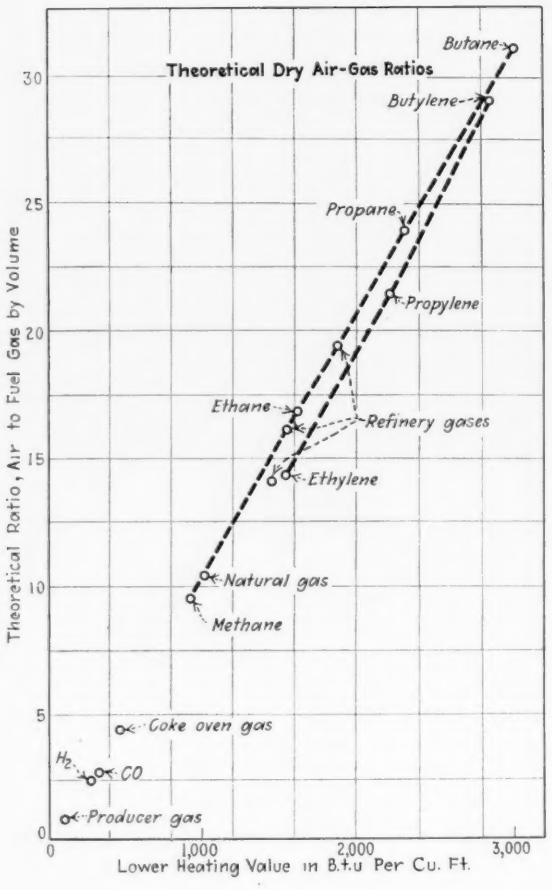
Where steam is generated at high pressure the lime soda treatment is supplemented with phosphates according to the Hall method in order to insure complete elimination of scale while preserving the sulphate-carbonate ratio needed to avoid embrittlement of the boiler steel.

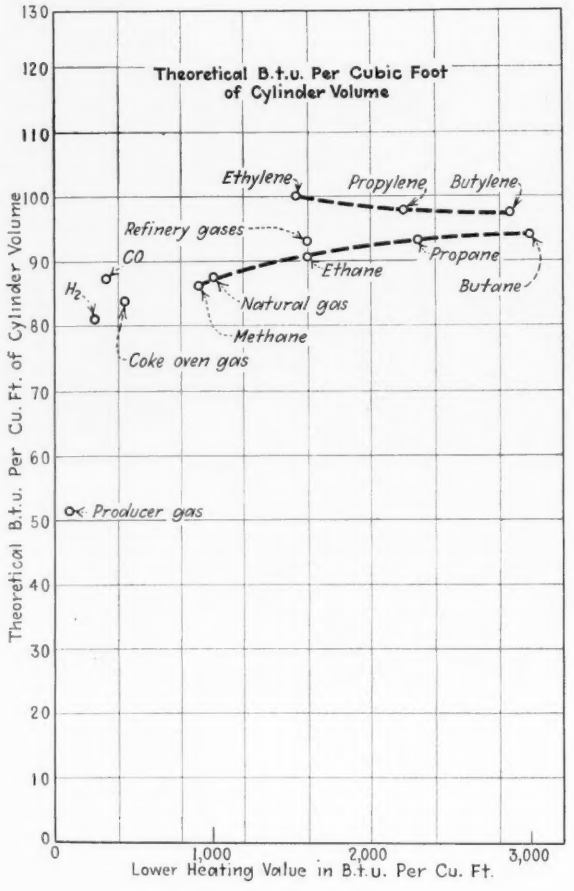
Deaeration can be combined with the heating of the water so that piping, economizers, boilers and turbines will be protected against oxygen corrosion.

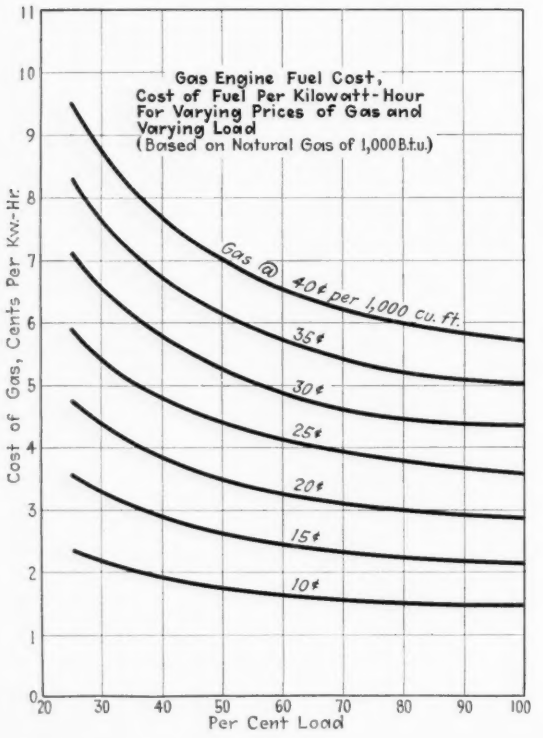
D-24

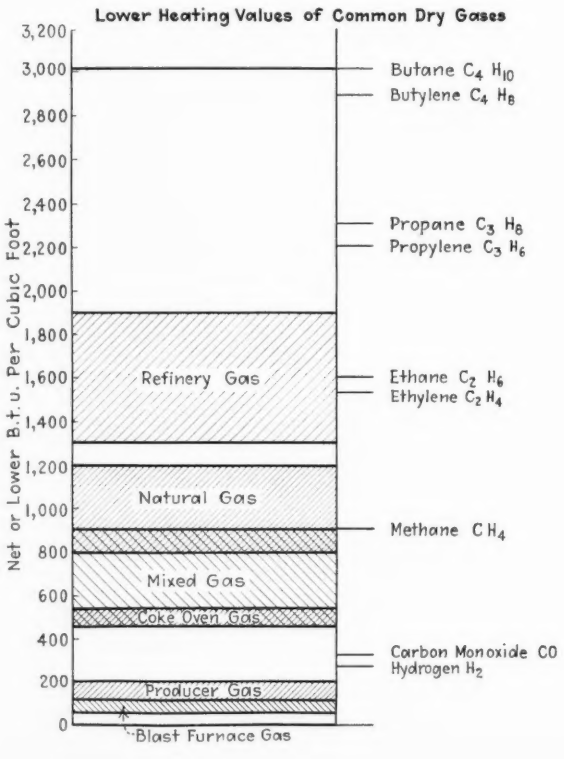
COCHRANE CORP. 17th & Clearfield Streets, PHILADELPHIA, PA.

FUEL GASES



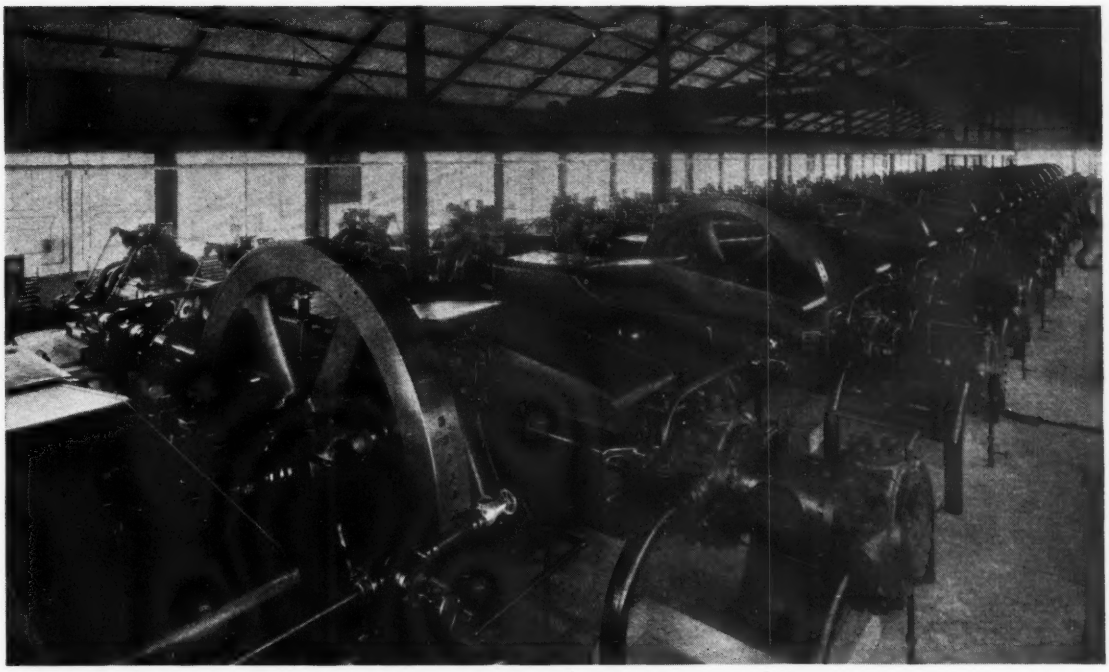






Courtesy of Worthington Pump & Machinery Corporation

© POWER



Twelve 24x36-in., 1,300-b.hp. gas engines at Fritch station on the longest and largest gas pipe-line, running from Amarillo, Texas, to Chicago. Gas compressors shown operate at 800 lb. per sq.in.

GAS ENGINES AND COMPRESSORS

By W. L. RUSSELL[1]
Manager, Oil & Gas Pipe Line Division
Worthington Pump & Machinery Corp.

AS A prime mover, the large gas engine holds a rather unique position, and in one highly special but large and important service, that of compressing natural gas, it has been practically without a rival. Hence its development and production for a period was limited to this particular field.

Now there are indications that it will again be on a fairly equal basis with other prime movers. Recent enormous extension in natural gas distribution has resulted in at least a partial restoration of this fuel to its previous favorable economic position. More careful and intensive cost analysis, proved by actual installations, has shown savings by the use of gas engines with mixed natural and manufactured gas or pure manufactured gas. Finally, it is probable that the increasing general effort toward highest efficiency and economy has in itself been the cause of renewed interest in the gas engine as a source of power.

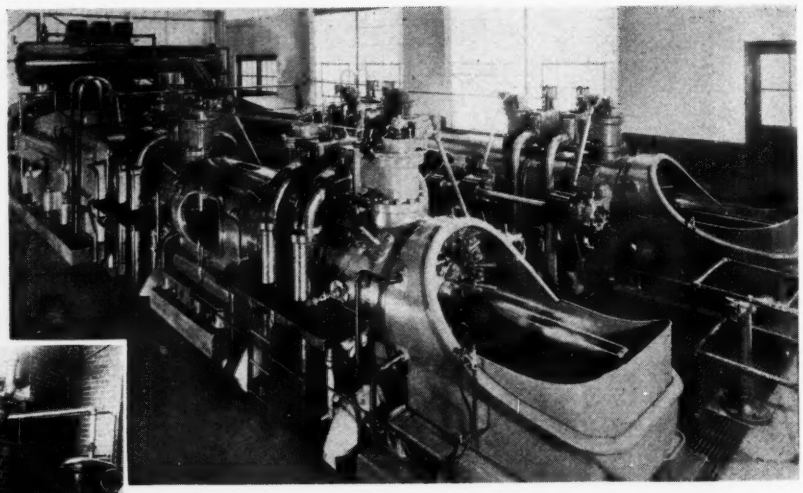
From the wide variety of types originally manufactured, the field has narrowed, for the large gas engine, to horizontal, double-acting, four-cycle units; four-cycle instead of two-cycle because of the inherent disadvantage of the two-stroke cycle when scavenging with mixture (although considerable progress has been made recently toward overcoming this defect), double-acting for the obvious saving in weight and cost per horsepower and in floor space. Horizontal instead of vertical for accessibility and for adaptation to cylinders in tandem with accompanying simplification of valve gear per cylinder. Except for very small sizes, tandem cylinders are necessary to reap full commercial advantage of the horizontal double-acting type.

Disadvantages of this type are greater floor space and slightly greater foundation mass. The decreased head room required offsets these disadvantages to some extent. Horizontal double-acting tandem types are somewhat restricted in range. The minimum size, on a basis of manufacturing cost, is about 300 hp., and the maximum, limited by possible bore and stroke of cylinders and because not more than four cylinders can be used, is about 10,000 hp. This, however, includes most ordinary installations.

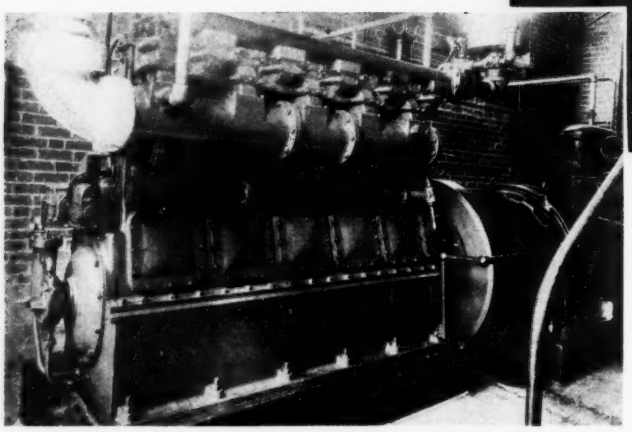
Horizontal, double-acting types have the advantage that one frame and running gear serves four single-acting cylinders, and the frame and running gear need be no stronger for four cylinders than for one. Fewer moving parts reduce maintenance and make parts more readily accessible. Alignment is not so important, since there are only two main bearings, or in the case of a single-tandem engine, one main bearing and one outboard bearing. Lubricating oil consumption is less, as there is no exposure of the crank case oil to the piston walls and liner.

With the recent increase in natural gas distribution has come the practice of mixing natural gas with manufactured gas in varying proportions. This involves raising the manufactured gas from atmospheric pressure, or slightly above, to the terminal line pressure of 15 to 25 lb. For this service, gas engines almost invariably show highest efficiency and are being widely used. They are

[1]An abstract of a paper, "Gas Engines and Gas Compressors," before the Metropolitan Section, A.S.M.E.



Gas-engine driven gas compressors, operating on refinery gas and pumping at high pressures, in the Chester plant of Philadelphia Electric Co.



A 5-cyl., 150-hp., vertical gas engine operating on natural gas and generating power for compressor and auxiliaries in Macon, Ga., ice plant

also being used in the distribution of straight manufactured gas, although in this case the operating cost of the gas engine is somewhat increased by the increased cost of fuel.

The recent increase in interest in the gas engine has led to efforts to make as many different types as there are diesels, each for its particular purpose, and based on diesel designs. This is economically and commercially sound to a fair degree. The objections are that while the explosion load is from 550 to 600 lb. per sq.in. in the oil engine, in the gas engine it is only 350 lb., thus there must be some economic loss in making a gas engine out of an existing oil engine. Otherwise, the oil engine must have been understressed in its first design or the cylinder spacing was excessive. To effect an equally efficient and economical design on the same running gear with both oil and gas cylinders requires a compromise and a consequent loss for both types. However, balanced against this loss is the initial saving in development and in manufacture by resulting duplication of many of the parts, including practically all of the running gear. This refers to engines built, sold and intended to remain as either oil or gas engines.

The change from one type to the other, after a period of service, is another question. (In discussion, Mr. Russell brought out that Worthington has recently completed design of an engine which can be converted from a gas engine to a diesel in four or five hours, only the pistons and the fuel injection system being changed. A gas-mixing valve replaces the fuel pump and shorter pistons are used for gas service—Editor).

In thermal efficiency the horizontal and vertical engine may be considered equal. In the case of direct-connected compressors, however, the horizontal type has the advantage of appreciably higher mechanical efficiency, because of the absence of the compressor running gear. This, coupled with the relative high cost of fuel, will show the horizontal unit of higher economic efficiency in gas compressor service for a manufactured gas plant.

Fuels cause no serious trouble in gas engine operation, since any gas likely to be encountered can be used efficiently. The only requirements are that the gas be supplied to the engine steadily, and at proper pressure, and that it be properly mixed with the air charge in the correct ratio.

Experience over a period of 30 years shows a pressure of 65 to 70 lb. brake m.e.p. can safely be carried by a properly designed and built gas engine. In fact, most larger engines built today can carry their sea level ratings at altitudes up to 5,000 ft.

In general power work, piston speeds of 900 to 1,000 ft. per min. are permissible, while for compressor work, due to limitations of compressor valve area and inertia of reciprocating weights, a piston speed of 750 ft. per min. has been standard for the larger sizes.

In recent years there has been a tendency towards battery ignition rather than the use of the old mechanical make and break, or the magneto. The most satisfactory ignition system so far devised is the low-tension distributor and storage battery with a small motor generator set floating on the line.

At the present time the large pipe line companies have their peak during the winter months, and during the balance of the year they must depend on the industrial load for their output. In order to improve their load curve, a dump load rate is being offered for the period where the load is light, and a higher rate for the heavy load period. This situation may therefore result in an average rate that is competitive with that of other fuels for the year, or may develop that a gas engine designed for the conversion to a diesel may be a good investment.

Studies have shown that with 30-cent gas and 10-hour, 100 per cent load factor, the cost is about one cent per kilowatt-hour for electricity generation by the gas engine. This compares with the diesel on the same load factor using 4.8 cent oil per gallon. Since unlimited reserves of natural gas are claimed available, and it is now being distributed in about 25 states, the operating advantages of the gas engine assume considerable importance. Its advocates claim lower maintenance, more reliable and uniform fuel supply and absolutely quiet operation. There are approximately 60,000 miles of trunk natural gas lines in the United States today, on which there is installed approximately 600,000 hp. in gas engines of 300 hp. and above. In 1929 the Department of Commerce reported a production of 1,568,139,000,000 cu.ft. of natural gas, and the gas business is second only to the electric power industry in capital investment and income.

LOOKING BACKWARD
To George H. Corliss

WHAT manner of man was George H. Corliss, whose name, cast on engine frames around the whole world, stands next to that of Watt in the minds of steam engineers everywhere? Turn back to Providence, R. I., in the early '70s, and see him in his prime, the Henry Ford of his day. Picture his shop, great for those days, a room 635 ft. long and 85 ft. wide.

The day's work has started. The end door opens. Down the shop walks an imposing man, tall, well dressed, smooth shaven, with shaggy eyebrows. This is George H. Corliss. His high silk hat, the hat he wore on all occasions, is tilted back on his head. The men catch this from the corners of their eyes, and those who can do so slip out of sight behind machines or columns. For the world of Corliss was out of gear when the hat was out of plumb. After the storm, when all was well once more, the hat slid forward and the workmen crept from their hiding places, no longer afraid to meet the boss.

Corliss had infinite pride in his engines, a pride that transcended all commercial considerations. Such little matters as collecting bills were often overlooked, but the money eventually came in, because people were honest. Almost in spite of his bad business habits, Corliss made money. He lived in a fine house and in all ways deported himself as a leader of the community.

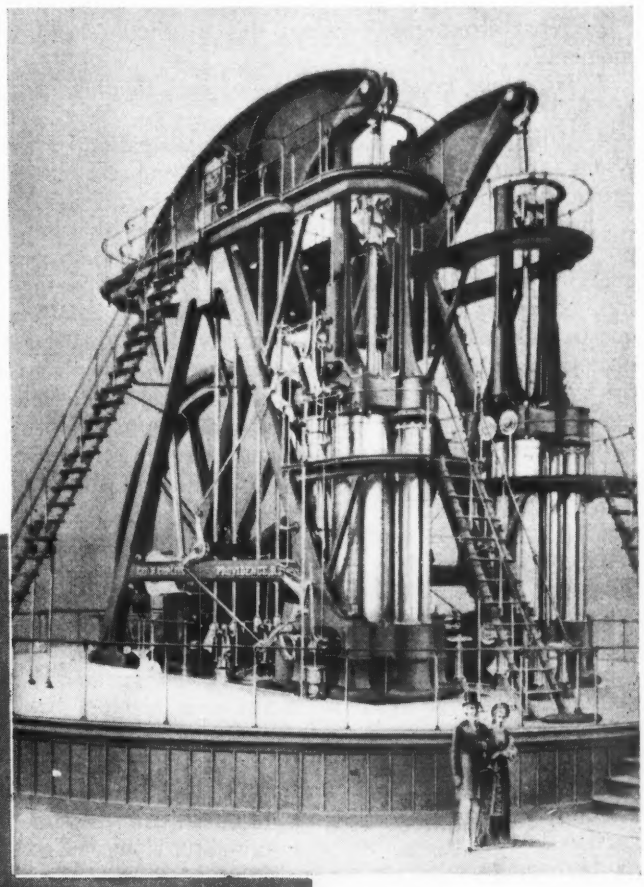
With Corliss, as with many other mechanical geniuses, revolutionary ideas were combined with extreme conservatism. He built and installed the great 1,000-hp. "Centennial" engine that took by storm the Philadelphia World's Fair of 1876. Yet, on threat of removing the engine, he forced the Exposition management to shut down all machinery on Sunday. Each Sabbath found the great engine covered with a tarpaulin.

Corliss' genius was by no means confined to engines. He invented a machine for sewing shoes. He developed to a high state of perfection a machine for shaping gear teeth. His shop turned the turret for the "Monitor," mystery ship of the Civil War.

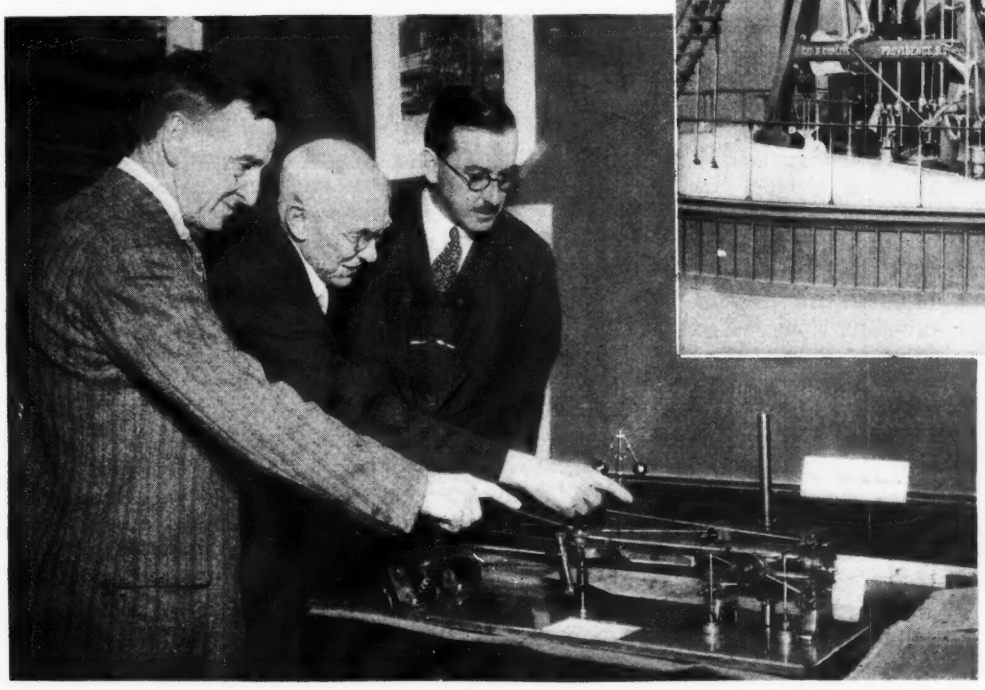
These are some of the high lights that came out of a meeting in Providence three weeks ago. At Brown University, under the leadership of Prof. James A. Hall and George W. Richardson, Corliss historians, a striking exhibition of photographs, documents, patents, drawings and working models was assembled. Hundreds of Providence citizens, including surviving co-workers of George H. Corliss, gathered for an evening of reminiscence.

Frank G. Tallman, vigorous vice-president and director of E. I. du Pont de Nemours & Co., enlivened the party with tales of his experience as assistant foreman under Corliss. Professor Hall summed up the achievements of the great engine builder. Other men spoke who had served under Corliss as draftsmen, machinists, or had operated his early engines.

It was a great meeting, one that may pave the way for a substantial memorial of this power pioneer. Some day, the hope was expressed, Washington may enshrine one of Corliss' pioneer engines, such, for example, as the Pawtucket pumping engine of 1878, still in good running condition.



The masterpiece of Corliss, his 1,000-hp. "Centennial" engine



John A. Gladhill (former pattern maker at Corliss works), Samuel D. Thayer (foreman for Corliss), Prof. James A. Hall (Corliss historian) view model shown at Centennial Exposition

PIPE DESIGN MADE EASY

By a New System of Charts

By E. A. WERT, S. SMITH and E. T. COPE
The Detroit Edison Company

THE charts in this article make it possible to determine piping tangent lengths for safe stresses and the anchor reactions for various temperatures. The charts shown apply to 90-deg. changes of direction only. Those covering other piping flexibility elements are being prepared by the authors.

To proportion properly a piping system that will carry hot fluids and, by its flexibility, will absorb the elongation resulting from rise in temperature, designers must answer these four questions:

1. At what point in the flexible member is the bending moment of maximum value?
2. What stress results from this maximum bending moment?
3. How long must the elements of each flexible member be?
4. What forces, resulting from the elongation of the piping, and the rigidity of the flexible member, must be provided for in anchoring the pipe line?

Answering these four questions constitutes the major portion of the piping designer's cares. The mathematical analyses[1] and calculations are complex and time-consuming. A set of curves has been devised by which these questions may be answered. These curves will greatly reduce the number of calculations necessary. They place in the hands of every piping designer an indispensable tool.

Nine forms of expansion members are usually employed in the design of piping in one plane. Only one of these will be considered in this article. It is shown in Fig. 1, Case A.

Fig. 1, Case A, represents a simple pipe connection between two fixed flanges at right angles to each other. The ends of the pipe member are held rigidly, which is the accepted condition assumed to hold for all piping design. The pipe in Fig. 1, Case A, is assumed to have been installed at 60 deg. F. and in such manner that neither thrusts nor moments at the ends resulted.

The expansion of the two elements, h and w, due to temperature change, produces thrusts and moments at the anchor points. In the analysis, the left-hand end is assumed anchored. At the right-hand end the fixed anchor is replaced by the force F_X acting along the axis of the element w, the force F_Z acting at right angles to the axis of w, and the moment M. These forces and the moment are shown in Fig. 2, replacing the anchor at the right-hand end of the structure. These two forces and the moment are of the exact values to hold the end c of the pipe fixed.

When the pipe assembly is heated to operating temperature the length in inches of the arm h increases by an amount $z = eh_1$ in which e is the elongation in inches per inch of the member due to the temperature rise, and h_1 is the length of h in inches: Similarly, the elongation of w is $x = ew_1$. These two values, z and x, are the hypothetical movements of the end c along the lines of F_Z and F_X, respectively. Each of the forces, F_Z and F_X, and the restraining moments due to the rigidity of the structure and its fixed ends, produce hypothetical deflections and rotations of the elements h and w.

When w is greater in length than h the maximum value of the bending moment always falls at a. Thus, the designer must proportion the members w and h of the structure so that the stress at a will not exceed a safe value.

In conservative piping design, for temperatures not in excess of 850 deg. F., 12,000 lb. per sq.in. is considered a safe value for the maximum fibre stress due to bending

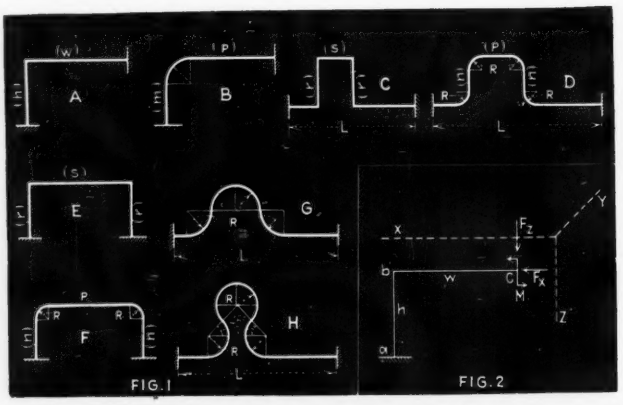


Fig. 1—Pipe elements used to absorb expansion. Fig. 2—Force diagram for Case A, Fig. 1

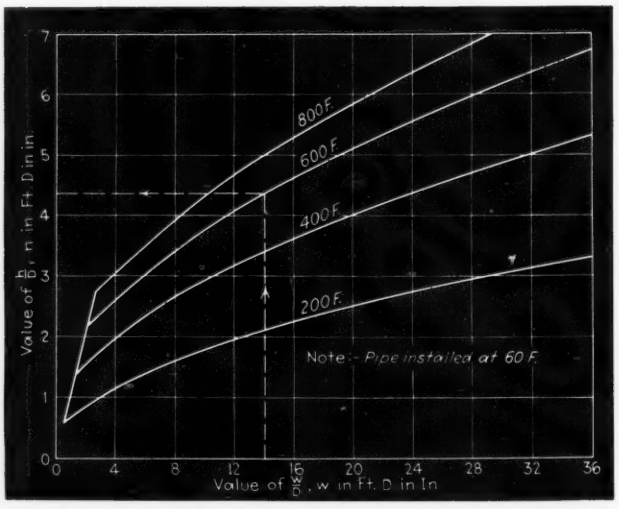


Fig. 3—Curves for finding dimensions of w and h that will limit bending stress to 12,000 lb. per sq.in.

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[1]The mathematical analyses for answering these questions are explained in detail in Chapter 7, Second Edition, *Piping Handbook*, by Walker & Crocker, McGraw-Hill Book Co.

alone. This value is not to be confused with the value of the total or combined stress due to pressure as well as bending. The stress due to pressure is a small portion of the total. In most cases it will not exceed 3,000 lb. per sq.in. The curves have been drawn on the basis of a stress of *12,000 lb. per sq.in. due to bending,* and will not hold for other stress values.

From the curves of Fig. 3 may be obtained the lengths of the arms w and h in feet, which will limit the maximum stress at a, due to bending, to 12,000 lb. per sq.in., caused by the elongation of the pipe when heated from 60 deg. to temperatures of 200, 400, 600 and 800 deg. F. In the curves the lengths of the arms w and h are given in feet, and the outside diameter of the pipe D is given in inches.

To use this chart the pipe diameter is assumed known, as is also the operating temperature. The length of one leg of the structure, such as Fig. 2, from the nearest anchor point, is fixed or selected. Calling this length w, $\frac{w}{D}$ is easily calculated. Suppose $\frac{w}{D}$ equals 14. Find 14 on the horizontal scale of Fig. 3. Follow from this point vertically until the curve of the desired temperature is reached. Pass left from this point on the curve and read its ordinate. This is $\frac{h}{D}$. The value of h is then calculated, remembering that D is the outside diameter of the pipe in inches. Thus, if the operating temperature of the pipe is 600 deg., in the case cited, $\frac{w}{D} = 14$, and $\frac{h}{D} = 4.4$ or h in feet = 4.4 times D in inches. Thus, if the diameter of the pipe were 10 in., $D = 10.75$ in., the length of the arm w would be 150.5 ft., and the length of the arm h would be 47.3 ft. With these dimensions the stress at a under an operating temperature of 600 deg. would be 12,000 lb. per sq.in., due to bending moment.

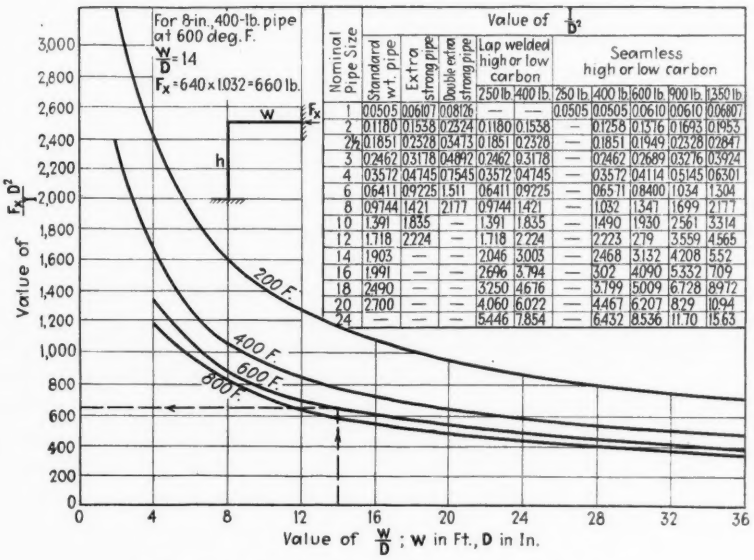
The next step is to determine the reaction forces F_X and F_Z. This can be accomplished by the use of the curves shown in Figs. 4 and 5 together with the tabulation which gives the values of the moment of inertia divided by the diameter squared for all ordinary sizes of pipe and customary wall thicknesses. These curves apply to the structure Fig. 1, Case *A*, when w and h are proportioned by the method just described.

To obtain the value of the force F_X, proceed as follows: Find the value of w/D, where w is feet and D inches, as was done for the curves in Fig. 3. Then on Fig. 4 draw a vertical line from value w/D to the curve of the temperature at which the pipe is to operate. Draw toward the left a horizontal line from the point on the temperature curve, and read the value of $\frac{F_X D^2}{I}$. Values of $\frac{I}{D^2}$ for all ordinary sizes of pipe are shown in the tabulation, and by multiplying the value of $\frac{F_X D^2}{I}$ found from the curve, by the value of $\frac{I}{D^2}$ found in the tabulation for the weight and size of pipe under consideration, the value of F_X is found.

For example, assume $w/D = 14$ for an 8-in., 400-lb. A.S.A. standard seamless steel pipe operating at 600 deg. F and as determined from Fig. 3 $h/D = 4.4$. From abscissa value 14, Fig. 4, proceed vertically to the 600-deg. curve, and then toward the left horizontally and read $\frac{F_X D^2}{I}$. This value is 640. From the table the value $\frac{I}{D^2}$ for an 8-in., 400-lb. seamless pipe is 1.032, and $640 \times 1.032 = 660$, which is the value of the force F_X in pounds. To find the value of the force F_Z, the same procedure is followed, using, however, the curves of Fig. 5. In the example given, $\frac{F_Z D^2}{I}$ is found to be 93 from the curve, and the force F_Z equals 93×1.032, or 96 lb.

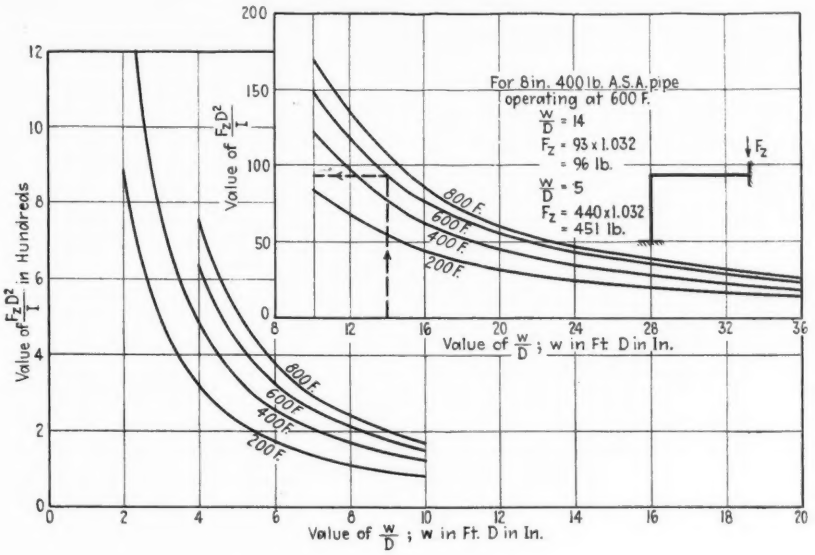
The curves shown here are obtained by rigorous mathematical solution, and accuracy of the answers depends only on the degree of accuracy in their use.

Fig. 4—Curves for determining anchor reaction *Fx*



Nominal Pipe Size	Value of $\frac{I}{D^2}$										
	Standard wt. pipe	Extra strong pipe	Double extra strong pipe	Lap welded high or low carbon		Seamless high or low carbon					
				250 lb.	400 lb.	250 lb.	400 lb.	600 lb.	900 lb.	1350 lb.
1	00505	00607	00826	—	—	0.0505	0.0505	00610	00610	00680
2	01180	01538	02324	01180	01538	—	01258	01316	01693	01953
2½	01851	02328	03473	01851	02328	—	01851	01949	02328	02847
3	02462	03178	04892	02462	03178	—	02462	02689	03276	03924
4	03572	04745	07545	03572	04745	—	03572	04114	05145	06301
6	06411	09225	1511	06411	09225	—	06571	08400	1034	1304
8	09744	1421	2177	09744	1421	—	1032	1341	1699	2177
10	1391	1835	—	1391	1835	—	1490	1930	2561	3314
12	1718	2224	—	1718	2224	—	2223	279	3559	4565
14	1903	—	—	2046	3003	—	2468	3132	4208	552
16	1991	—	—	2696	3794	—	302	4090	5332	709
18	2490	—	—	3250	4676	—	3799	5009	6728	8972
20	2700	—	—	4060	6022	—	4467	6207	829	1094
24	—	—	—	5446	7854	—	6432	8536	11 70	1563

Fig. 5—Curves for determining anchor reaction *Fz*


For 8 in. 400 lb. A.S.A. pipe operating at 600 F.
W/D = 14
Fz = 93 x 1.032 = 96 lb.
W/D = 5
Fz = 440 x 1.032 = 451 lb.
Fz
800 F.
600 F.
400 F.
200 F.
Value of FzD²/I in Hundreds
Value of FzD²/I
Value of W/D ; w in Ft. D in In.

U. S. STEAM $$ IN BALTIMORE

By EUSTIS H. THOMPSON
Consulting Engineer

The boiler plants in the Baltimore Post Office and Customs House have been shut down for a year's test of purchased steam. At *Power's* request Mr. Thompson compares the estimated costs of purchased and locally generated steam. He concludes that the expected saving may prove to be a loss

BALTIMORE'S new limestone Post Office and Court House Building was occupied on May 28, 1932. The up-to-date stokered heating plant, which operated during the winter construction period, was, however, shut down, and steam for heating is supplied by the Terminal Heating & Freezing Co., a subsidiary of the Consolidated Gas, Electric Light & Power Co.

Steam costing approximately 74 cents per 1,000 lb. has replaced steam from the local plant, which cost about 56 cents per 1,000 lb. Fixed charges have not been included in the cost of steam from the local plant, as the fixed costs represent an investment that must be charged for whether or not steam is generated in the Post Office plant. As a matter of fact, fixed charges are higher with utility steam, as additional equipment and piping are necessary for its use.

Loss to the Post Office, however, is partly balanced because district steam is sold under the same contract to the Customs House and Appraisers Building. The hand-fired plant supplying these latter buildings is considerably less efficient than the new stoker installation.

The purpose of the Treasury Department in making this one-year contract was to find out by actual trial how the cost of purchased steam will compare with that estimated from their data on local plants. The utility company, however, guaranteed that the cost for steam during the year would not exceed $26,870.80. Data collected during the year would then reveal the advisability of making a continuing contract.

Figures presented by the Comptroller-General of the Treasury Department, as given in Table I, show that utility steam costing $26,870.80 will be $210.50 cheaper than the average yearly cost of locally generated steam. A trial, according to this estimate, costs nothing, except for the fact that over $9,000 was spent for control equipment to utilize district steam efficiently, for the installation of 400-ft. of 8-in. underground mains between the two buildings, and two new electrically-driven pumps at the Customs House plant, the latter part of which will be a wasted expenditure if a continuing contract for district steam is not made.

Data given by the Comptroller-General in Table I compares the cost of steam generated in the local plant with the cost of utility service, which is based on the assumption that improved heating efficiency will be secured by reason of the installation of control equipment. Such a comparison is an unfair one. Either the cost of operating the local steam plant should be based on the generation of the same amount of steam as the utility expects to supply, or else the utility figures should be based on the amount of steam found necessary to supply from the local steam plant without heating system control.

There are several other items of cost, as shown in Table I, that might well be taken exception to. Item 1, Table I, covers $450 for repairs to three boilers, each of 1,500 sq.ft. of heating surface. Maintenance cost figures from other plants of approximately the same size indicate this to be considerably high. It is estimated that $200 should amply cover boiler repairs. This item of boiler repair is included, although, of course, during the first year of operation it is unlikely that this amount of money would be expended for repairs, but it may be taken as a maintenance cost that would be an average over a considerable number of years.

Likewise, a more reasonable figure for stoker maintenance would seem to be $266 instead of $366 shown in Item 2 of Table I.

In the Treasury Department's cost estimate, $1,800 is provided in Item 3 for redecorating and additional cleaning due to the handling of coal and ashes in the building. In the large building near the Post Office it has been observed that practically all the dirt is derived from the usual atmospheric condition, rather than smoke and ashes from a nearby stoker-fired plant. The building superintendent considers that shutting down the steam plant would make no appreciable difference in cost of cleaning the building.

Some expense would be involved in cleaning the graveled roof due to plant operation. However, since the boilers have been shut down, smoke of approximately No. 2 Ringleman density is caused by the incinerator. Thus, it would seem that a charge of $1,000 for additional cleaning, due to operating the steam plant, would be amply sufficient.

The heating plant at the Customs House consists of two hand-fired water-tube horizontal boilers of 2,400-sq.ft. heating surface each, which serve 21,818 sq.ft. of radiation. The costs of repairs and supplies for these boilers, as shown in Items 4 and 5 of the Comptroller's operating cost estimate, Table I, seem out of line with actual repair costs encountered in the average boiler room of this size. These costs could be reduced to $380 and $200, respectively, for repairs and supplies, and still be conservative.

The effect of these changes in the operating costs shown by the Treasury Department is given in Table II. The net result indicated is a saving of $1,089.50 per year through operation of the two local plants, over what it would cost to use utility steam under the guaranteed cost of $26,870.80.

Table I—Treasury Department Estimate of Cost of Heating Baltimore Federal Buildings

			Item No.	
Post Office Building				
Coal 1830 ton @ $3.95		$7,228.50		
Ash removal, 366 cu.yd. @ $0.85		311.00		
Labor, 2 firemen @ $1,680	$3,360			
1 fireman @ 1,620	1,620			
1 fireman @ 1,560	1,560			
		6,540.0		
Boiler repairs, 4,500 sq.ft. @ $0.10		450.00	(1)	
Stoker maintenance, 1,830 tons @ $0.20		366.00	(2)	
Stoker power, 1,830 tons @ 10 kw.-hr. per ton @ $0.055		274.50		
Supplies		200.00		
Redecorating cost, additional cleaning, etc., due to the handling of coal and ashes in building		1,800.00	(3)	
				$17,170.00
Customs House and Appraisers Build ng				
Bituminous coal 480 ton @ $4.81		2,308.80		
Anthracite coal 450 ton @ $3.25		1,462.50		
Ash removal 350 cu.yd. @ $0.80		280.00		
Labor 2 firemen @ $1,500	$3,000			
1 fireman @ 1,380	1,380			
		4,380.00		
Boiler repairs 4,800 sq.ft. @ $0.10		480.00	(4)	
Supplies		250.00	(5)	
Redecorating cost, additional cleaning, etc. due to the handling of coal and ashes in building		750.00	(6)	$ 9,911.30
Total				$27,081.30
Purchased steam, guaranteed maximum cost				$26,870.80

Table II—Correction of Heating Costs in Table I

Post Office Building

	As Charged	Corrected	Amount Lowered
Boiler repairs 4,500 sq.ft. @ $0.10	$450.00	$200.00	$250.00
Stoker maintenance 1,830 tons @ $0.20	366.00	266.00	100.00
Redecorating costs	1,800.00	1,000.00	800.00
Total estimated reduction			$1,150.00
Corrected cost per year of Post Office plant $17,170.00—$1,150.00 =			$16,020.00

Customs House and Appraisers Building

	As Charged	Corrected	Amount Lowered
Boiler repairs 4,800 sq.ft. @ $0.10	$480.00	$380.00	$100.00
Supplies	250.00	200.00	50.00
Total reduction			$150.00
Corrected cost per year of Customs House plant $9,911.30 — $150.00 =			$9,761.30
Corrected Cost of both plants			$25,781.30
Purchased steam cost, guaranteed maximum			$26,870.80
Saving by local steam generation			$1,089.50

Table III—Cost of Utility and Locally Generated Steam Compared

(Figured from Table No. 1)

	Total Yearly Cost, from Table I	1,000 Lb. Steam per Year	Steam Cost, Cents per 1,000 Lb.
Post Office	$17,170.00	35,500	48
Customs House	9,911.30	12,530	79
Total	$27,081.30	48,030	56
Utility Steam, Max. Guaranty	$26,870.80	36,300	74

Cost Comparison on Basis of Equal Steam Supply

	Based on 48,030,000 Lb. Steam per Year, No Control Devices		Based on 36,300,000 Lb. Steam per Year, As Used *with* Control Devices	
	Total Cost	Cents per 1,000 Lb.	Total Cost	Cents per 1,000 Lb.
Local plants	$27,081.30	56.5	$21,562.00	59
Utility Steam	$32,300.00	69.1	$26,871.80	74
Loss due to Utility Steam	$5,219.00	....	$5,309.00	

If utility steam is not continued after the initial year's contract, an additional loss of $5,000 will be incurred, as the extension of the steam main and installation of valves, strainers, tanks and pumps, necessary to give utility service to both buildings, would become useless if the buildings are heated with local steam. In this event, the additional cost of utility steam over local steam would be $6,089.50.

Even with the revision shown in Table II, the comparison of the cost of utility steam and locally generated steam is not a fair one, since the fuel consumption in the case of the local plant is computed on the basis of the steam supply required by a building without heating system control, while the cost of utility steam is based on a steam consumption that has been decreased about 25 per cent by the installation of control equipment. In Table III the costs of steam are compared when both the utility and the local plant supply the steam that would be required if the heating systems of both buildings operated without control. The lower part of this table gives a similar comparison of costs if both heating systems operated with control equipment.

The cost of steam from the local plant is calculated according to the cost given by the Treasury Department in Table I. Steam consumption figures were not given in the Treasury Department's report, but can be calculated from the total consumption figures given.

The combined stoker and boiler units in the Post Office Building were guaranteed to give an average efficiency of 75 per cent. Assuming, however, a day-in and day-out efficiency of 70 per cent when burning a coal of 13,800 B.t.u. per lb., a yearly consumption of 1,830 tons of fuel will generate 35,500,000 lb. of steam at 15-lb. gage from feed water at 200 deg. F. In the Customs House a mixture of bituminous coal, having a heating value of 14,300 B.t.u., and anthracite screenings of 12,500 B.t.u. are hand-fired. Assuming the same steam conditions, and allowing an efficiency of 50 per cent, 12,530,000 lb. of steam would be generated from the 930 tons of coal fired. Thus, the total steam supplied to both buildings is 48,030,000 lb. per season.

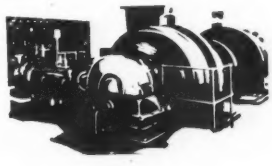
The average base price for this amount of steam, when supplied by the utility, is 72 cents per 1,000 lb. Assuming a conservative figure of 70 cents per 1,000 lb., the 48,030,000 lb. of steam would cost $33,621. To this must be added an annual "readiness to serve" charge of 5 cents for each square foot of equivalent radiation. Based on a total of 79,217 sq.ft. of radiation, as given by the Treasury Department, the "readiness to serve" charge is $3,961. The sum of these two charges is $37,582, from which must be subtracted a fuel adjustment charge of 7½ cents per 1,000 lb. and 5 per cent for prompt payment, leaving a net cost of $32,300. No charge is made for interest on the $9,000 invested for pipe connections, new pumps, control equipment, etc.

Comparing this cost of $32,300 for 48,030,000 lb. of utility steam against the $27,081.30, the cost of this same amount of steam as taken from the Treasury Department's figures, it would seem that a net loss of $5,219 is incurred by the purchase of utility steam.

If control equipment is installed on the heating system, the steam required, as determined from the requirements of other buildings using the control equipment, would be 36,300,000 lb., which, at the regular published rate for steam, would cost $26,870.80, or the maximum cost guaranted by the utiltiy. In obtaining the cost of this amount of steam when generated by the local plant, it was assumed that one fireman is dropped at the Post Office, and that all other costs are reduced in proportion to the reduced evaporation. Compared on this basis, as shown in Table III, locally generated steam costs $5,309 less than utility steam.

By installing stokers, steam could actually be fur-

(Continued on page 204)



AUTOMATIC COMBUSTION

Keeps Steam

Although it depends upon a decrease in steam pressure for the initial impulse to change the rate of air flow and fuel feed, this system differs from most others in that the control functions to return the steam pressure to normal value

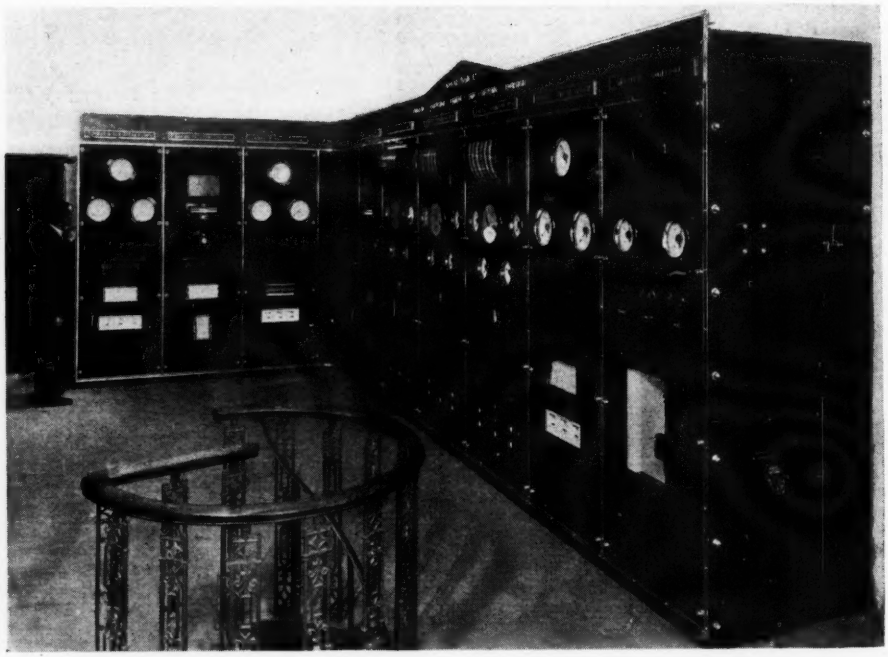


Fig. 1—Automatic combustion-control and boiler-meter panel board in Hackney Station

BOTH in the United States and in Europe, several systems of automatic combustion control have been developed and are in successful operation. Most of these systems obtain their initial impulse for an increase or a decrease in the combustion process from a change in steam pressure. If the demand for steam increases, it causes a slight drop in the header pressure. This reacts on a master controller that puts into operation a series of events to supply the necessary heat to the boiler to maintain the steam pressure at or near normal. When load is taken off the boilers, the rise in steam pressure causes the master controller to function to slow down the combustion process and bring the steam pressure to near rated value.

Most automatic combustion-control systems do not bring the steam pressure back to normal, but allow a small deviation from rated value. That is, at light loads the steam pressure may be two or three pounds above, whereas at heavy loads the pressure is slightly below, normal. This differential of pressure is essential to the functioning of the master controller. An anticipatory-type automatic combustion control system recently developed by George Kent, Ltd., Luton, England, obtains its initial impulse for the master controller from a change in steam pressure as for the other types, but it also functions to restore the steam pressure to a constant value.

Parts of this equipment comprise practically the same units as found in other types. They include a master controller that regulates the induced draft, a fuel-air ratio controller and a furnace-pressure controller. Impulses from the master regulator to the other parts of the control are transmitted electrically.

One difficulty in the operation of a constant-pressure combustion-control system is hunting. This has been overcome in the Kent system by having the master controller govern by a series of impulses. If the pressure is decreasing, which indicates an increase in heat demand, the master controller sends a series of impulses to the induced-draft fan and damper controller to speed up the combustion process.

These impulses are graded according to the severity of the steam demands, as indicated by the pressure changes. The greater the drop in pressure the longer the impulse will last. When the steam pressure begins to rise again, the impulses decrease in length, and when the pressure reaches normal they cease. This, however, would not be sufficient to prevent the pressure from overshooting and going too high or to keep the system from hunting. To do this the master regulator contains a gradient control that superimposes gradient impulses upon the pressure impulses.

With falling pressure the gradient impulses do not influence the pressure impulses, but when the steam pressure starts to rise the gradient impulses are reversed and subtract from the pressure impulses. As the steam pressure approaches normal the gradient impulses become greater than the pressure impulses, so that there is a slowing down of the combustion process to that necessary to maintain a constant pressure. By this means a rapid response of the control is obtained according to demands for changes in combustion without hunting.

CONTROL

Pressure Constant

Fig. 2 shows a section through the master controller. Steam pressure is transmitted by oil to a piston P. This pressure is balanced against the weight W. To eliminate the effect of friction between the pressure piston and the weight, the piston is rotated by the motor M. Above the weight W are two sets of contact arms. On one side of shaft S are three pressure-impulse contact arms, A, A_1 and A_2, all in the same vertical plane. On the other side of shaft S are the three gradient-impulse contact arms, B, B_1 and B_2, also arranged in a vertical plane.

Contacts A and B are pivoted on shaft C and attached to weight W and are raised and lowered with it as the steam pressure changes. Pressure-impulse contact arms A_1 and A_2 and gradient-impulse contact arms B_1 and B_2 are cam driven by motor M causing them to advance simultaneously toward contacts A and B respectively, and then return to the full-open position. When the steam pressure is normal, contact A is midway between A_1 and A_2, likewise B is central between B_1 and B_2.

Consider the pressure impulses: When contact arm A is in its central position, pressure impulse arms A_1 and A_2 will advance and touch it simultaneously and no impulse will be given, since arm A_1 tends to give a rising impulse and arm A_2 a lowering impulse. When there is a decrease in steam pressure, weight W takes a lower position and with it arms A and B.

Now, when arm A_1 advances it meets A and remains in contact with it for a period depending upon how much the steam pressure has dropped. If the decrease in steam pressure is small the contacts will remain closed for only a short period to give a small raising impulse to the combustion-control system.

On the other hand, if the drop in steam pressure is comparatively large, contact A will be in a correspondingly lower position. When contact A_1 advances, it will remain in contact with A proportionally longer and will give a corresponding raising impulse to the combustion system. If the pressure continues to decrease, arm A takes a still lower position, and the raising impulse will become longer until the rate of supplying heat to the boiler has increased to a point where the pressure ceases to decrease and starts to return to normal.

While the pressure is decreasing, the gradient-impulse contacts are also functioning. Gradient-impulse contact B is attached to weight W through a friction clutch that allows it to change its position relative to arm A. When the pressure starts to decrease, arm B drops to the same position as A. However, after A has been in contact with A_1 it retains its lower position, but when B contacts with B_1, the clutch slips and B is raised.

If the pressure continues to decrease, or the second impulse contact A_1 remains in contact with A for a longer period, as previously explained, B will be in contact with B_1 for a period corresponding to the change in pressure between the first and second impulses. Contact B will also be pushed to a higher position on its pivot shaft. When the pressure ceases to drop, contacts A and A_1 will be giving a maximum raising pressure impulse and B and B_1 will just touch momentarily, because B has been rotated upward on its pivot shaft an amount corresponding to the lower position of weight W, due to the fall in steam pressure.

When the pressure begins to rise, weight W will take a higher position, as will also contacts A and B. This means that contact B is now in a position above the horizontal. Consequently, when the impulse contacts advance

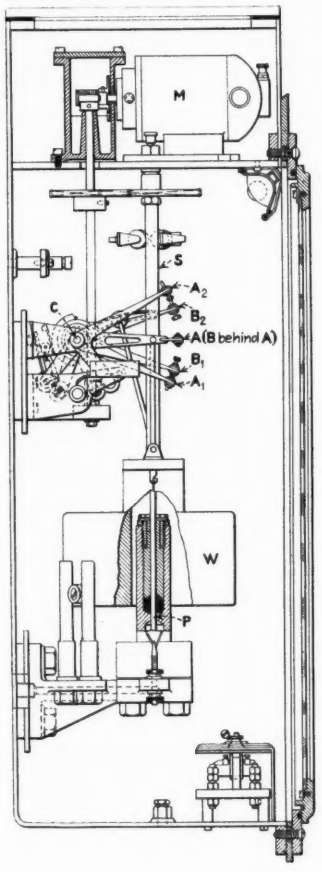


Fig. 2—Cross-section through master controller for Kent automatic combustion-control system

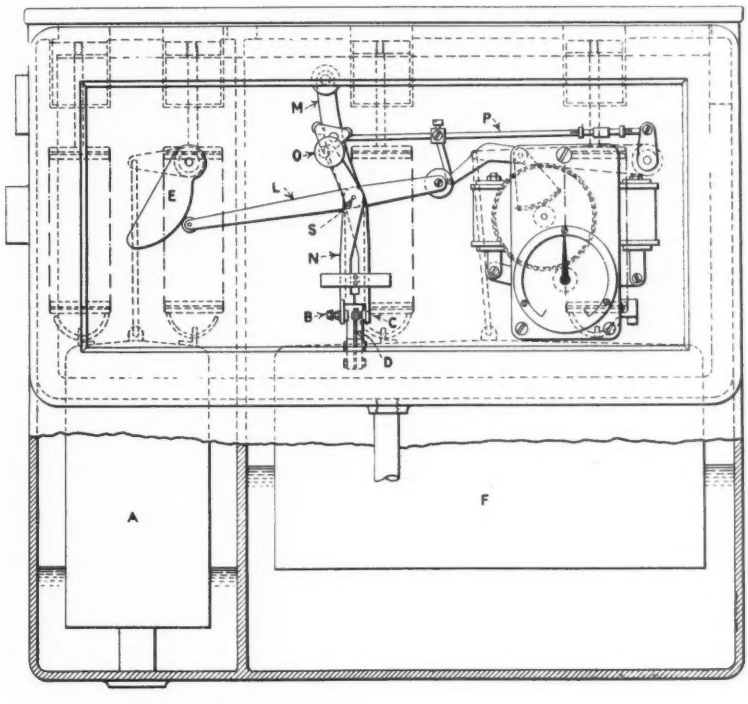


Fig. 3 — Air-fuel ratio controller for automatic combustion-control system

to meet A and B, contact A_1 will meet A and give a raising impulse and B_2 will meet B and give a lowering impulse. The effective raising impulse is the difference between A and B, consequently, the slowing up in the combustion process is faster than the increase in pressure.

As the pressure returns more closely to normal the lowering impulse will be greater than the raising impulses. When this occurs the lowering impulse has control and there is a slowing down in the combustion process so that the steam pressure comes to its original value without overshooting or hunting of the automatic control.

When the pressure rises, as with a rejection of load, weight W and contacts A and B take a higher position. Then contacts A_2 and B_2 deliver lowering impulses to the combustion process to bring the steam pressure to normal again. Suitable adjustments are provided in the control so that the gradient impulses can be varied in their relation to the pressure impulse to meet the requirement of the load.

The master controller acts directly on the induced-draft-fan controller or on the uptake damper to vary the induced draft and change the air flow through the furnace. The change in induced-draft causes a change in furnace pressure which acts on a furnace-pressure controller. This controller comprises an oil-sealed bell, the interior of which is acted upon by the pressure in the furnace. The weight of the bell is balanced on springs and carries a movable contact supported between two stationary contacts.

If the induced draft is increased, the furnace pressure drops and the bell in the furnace pressure controller takes a lower position and closes one of its contacts to increase the speed of the forced-draft fan and restore the furnace pressure. If the steam pressure is rising and the master controller reduces the induced draft, the furnace pressure increases and this controller acts to slow down the forced-draft fan to provide the correct furnace pressure.

To maintain the proper ratio between the air flow and fuel, an air-fuel ratio controller is used to regulate the rate of fuel feed. The air-fuel ratio controller, Fig. 3, includes two oil-sealed bells. One of these, the air bell A, is connected to the forced-draft duct and the other, the fuel bell F is acted upon by air pressure from a small fan driven by the fuel-feed mechanism. When the fuel and air are in the correct ratio the two bells are in a balanced position. On a shaft S are pivoted three levers L, M and N. Lever L carries contact C controlled by cam E operated by air bell A. Lever M is operated by fuel bell F and carries central contact D. Lever N supports contact B and is operated by weight O biasing contact B against central contact D. The arms that carry contacts B and C have a scissors action and are prevented from closing by limit stops. On the right-hand end of lever L is a counterweight to hold its opposite end against cam E that is turned by the movement of bell A.

Assume that the air flow to the furnace has been increased. This will cause a drop in air pressure under bell A and it will start to descend and turn cam E in a clockwise direction. In so doing, lever L is rotated at axis S, contact D makes with C and causes the control to begin increasing the speed of the fuel feeder or stoker. When the fuel feed has increased to correspond to the air flow, the small fan driven by the fuel-feed mechanism is at a speed to reduce the pressure under bell F to again restore the balance in the control, and contact D returns to a central position between B and C. To slow the fuel feed down the process is the reverse, and contact D makes with B.

On the right-hand side of the fuel-air ratio control is an electric dial mechanism that allows adjusting the air-fuel ratio by push-button control, to suit different grades feed or fuel-bed thicknesses. The percentage of excess air is adjusted by changing the contour of cam E through pushing lever P on cam lever M. For example, the cam may be shaped to give 25 per cent excess air when the boiler is operating at normal rating and 40 per cent at light loads.

The photograph, Fig. 1, shows the automatic control panel in the Hackney station in England for the control of three stoker-fired boilers normally rated 125,000 lb. of steam per hour at 400 lb. per sq.in. and 800 deg. F. On the right is the master control panel with the master controller on the lower part of the panel. Just above the master controller are three switches, two for selecting either automatic or manual control. At the top of the panel is an indicator to show the length of the impulses sent out by the master controller. The next panel mounts steam-flow and pressure meters. On the lower section of the next three panels are indicating lights and automatic control switches for control of the fans and stokers and switches for setting the air-fuel ratio. Above the switches are the draft, CO_2 and other gages. The left-hand panel mounts a 48-point pyrometer for the boilers. In addition to panels mentioned are three others on which are mounted indicating and recording instruments for feedwater and condensate flow, steam and feedwater temperatures and steam flow.

Information for this article was supplied by A. V. Hemmens, engineer, Drummond, McCall & Co., Ltd., Montreal, Canada, representative for George Kent, Ltd., in Canada and the United States.

U. S. STEAM DOLLARS IN BALTIMORE

(Continued from page 201)

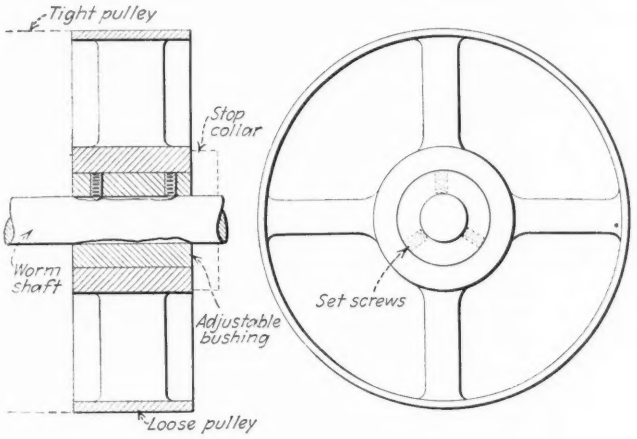
nished by the Customs House plant for nearly the same as that given in Table I for the Post Office, or, say, 55 cents per 1,000 lb., not including interest on the cost of the stoker. At this rate the steam used by the Customs House would cost $6,900 per year. The total savings by a stokered plant would then be $3,000 over that by district steam, which would probably pay for the stokers in less than two years.

It would seem that a more logical procedure for the Treasury Department to have followed would have been to operate the Post Office plant for the first heating system, and then to have compared its actual cost with the maximum guaranteed cost for utility steam. The comparisons would also seem to show that a more profitable investment for the $9,000 expended in making it possible to use district steam would have been the installation of stokers in the Customs House plant, and the installation of heating system control. If a regular contract were entered into, operation with utility steam would cost about $5,000 a year more than would operation with locally generated steam, using the same or equivalent control devices.

PRACTICAL AIDS TO OPERATION

Adjustable Bushing Placed in Loose Pulley

WHEN a rattling loose pulley was removed to put in a bushing it was found that the shaft was also badly worn. The shaft could not be removed without considerable difficulty and expense. The condition of the shaft at first raised the question of the possibility of bushing the



pulley without renewing the shaft, but the problem was solved by making an adjustable bushing, as shown in the diagram.

The adjustable bushing was made of steel with a ½-in. wall and was tapped for six headless set-screws placed in equidistant pairs. I then bored the pulley to fit this bushing with a running fit and cut an oil groove in it.

To assemble the adjustable bush it was first put into place and the set-screws tightened. The bushing was then removed and flat spots were filed on the shaft where the screws made contact. After this operation the bushing was put back into position and the six screws adjusted to make the bushing run true. When the screws were properly tightened I peened in the top of each hole so that there would be no chance of the screws working loose and scoring the pulley. The bushing has remained tight and the pulley is working as well as when new.

Hamilton, Ont. H. MOORE.

Voltage Control of Small Hydro-Electric Generators

SOMETIMES small water-turbine driven generating plants supplying current to small communities are operated without an automatic governor. There usually must be a man at the plant who watches the voltmeter needle and keeps the voltage under control by field excitation. That kind of regulation "gets by" fairly well with moderately constant loads, but there are occasions when the plant gets out of control. The speed increase due to load loss is rapid, anl may run up to as much as 100 per cent above normal in propeller types of turbines, with a nearly proportional voltage increase. In such cases there are usually quite a few lamp burnouts.

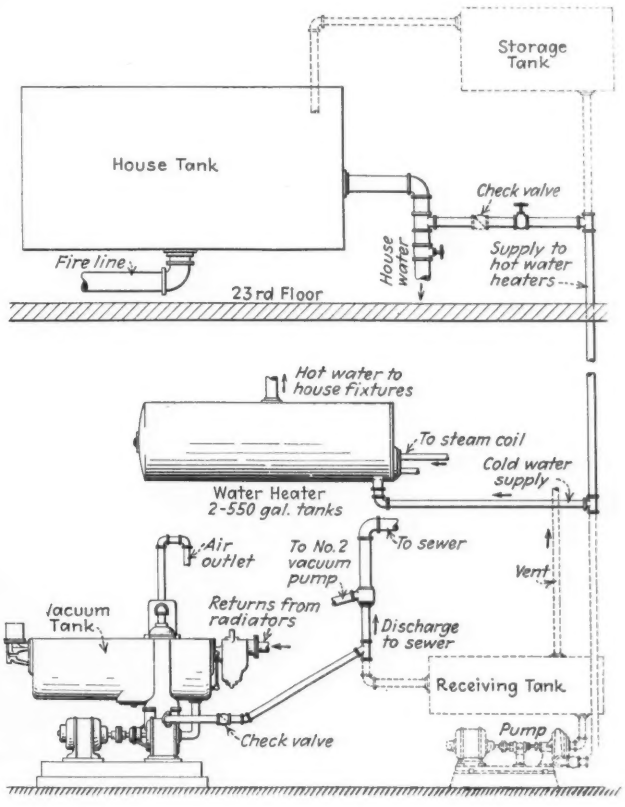
I have used a solenoid relay in the field circuit, which cuts in sufficient resistance to keep down the voltage to a point slightly above normal when the turbine is racing. This works well on both alternating- and direct-current plants and acts before the attendant starts to close the turbine gates. Another device used is to have an overvoltage relay connect a resistance bank, usually located in the tailrace, to keep the generator loaded.

York, Pa. J. S. CARPENTER.

Condensate From Heating System Used in Water Heater

IN A building where steam is purchased and the returns from the heating system are discharged to the sewer, it was decided to pass this water through the water heater for use in the building and thus save on the amount of water that had to be purchased. The dotted lines in the diagram show the changes made in the piping and the tanks added to save the returns. Instead of the return water being discharged to the sewer, it now goes to a receiving tank in the basement. From there it is pumped either directly into the heater or to a storage tank on the 23rd floor of the building.

In case there should be an excess of condensate from the heating system, which is not likely to occur, an overflow is provided from the storage tank into the house-



service tank. Any water required in the heater above that supplied by the condensate comes from the house-service tank through the check valve between the condensate and house-water lines. The installation was simplified by using the cold-water supply pipe to the water heater for the supply line to the storage tank. The cost of pumping water in the building was not increased, because all the water for the hot and cold services had to be pumped to the 23rd floor in either case. THOMAS SHEEHAN.

Nutley, N. J.

Interchange Bearing on Motor to Keep Machine in Service

A 15-HP. induction motor belted to an induced-draft fan blew its fuses. When the fuses blew they caused a short-circuit on their terminals and made replacement of the fuse block necessary. Examination of the motor showed that the bearing on the pulley end was worn so that it allowed the rotor to rub on the stator core, and that this was the cause of the blown fuses.

The motor had to be put back into service as soon as possible in order to keep the plant operating. As a new bearing was not available, it was decided to interchange the two bearings in their housings. This put the good bearing at the pulley. When this was done it was found that the rotor ran sufficiently clear of the stator to allow putting the motor back into service. A new fuse block was installed, the motor was started and it operated thus for two months before the bearings were renewed.

Toronto, Ont. L. W. Ross.

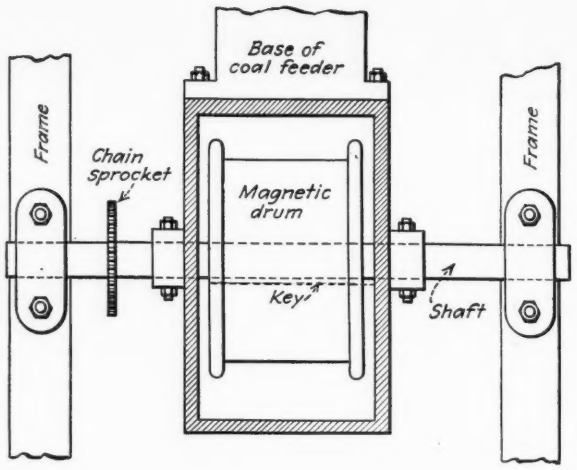
Syphoning Effect Increases Pump's Capacity

VALUE of the syphoning effect of water in reducing the electrical motor load on a pump was demonstrated in a practical manner near Vancouver, B. C., recently. The Lulu Island Slough Dyking Commission installed a 60-hp. pump to drain 4,300 acres. It had a rated capacity of 16,000 g.p.m., but delivered 17,000 under test. The outlet was placed at the bottom of the river and it was found that while the motor used up 50 hp. to start after a short time the syphoning effect caused by the outlet being under water reduced the pump motor load to 31 hp.

Vancouver, B. C. F. H. FULLERTON.

Piece of Concrete Jams Magnetic Separator

TROUBLE developed in a pulverized-coal burning plant which might occur in other installation if proper precautions are not taken. The plant referred to was one equipped with a unit system of pulverizers. A piece of concrete in the coal about 2 in. square either passed through the coal crusher or dropped into the coal bunker and then passed through the feeder until it started to pass the magnetic drum. Here it wedged between one end of the drum and the cast-iron casing and caused the speed change gears to jump out into neutral, thus preventing any further damage.



After the concrete was removed and the coal-feeding mechanism started, the chain driving the magnetic drum broke, and it was found impossible to turn the drum by hand when it should revolve easily. Upon removing the casing the drum was found to be forced endways on the shaft until its end face was binding on the housing. After centering the drum on its shaft a bronze collar was put at each end in the space between the housing and the ends of the drum, to prevent the drum being pushed along the shaft again. HARRY M. SPRING.

Milford, N. J.

Recording Instruments Improve Power Plant Operation

RECORDING instruments and meters in large or small power plants are almost indispensable if accurate cost and operating records are to be maintained. My experience with recording instruments has been satisfactory. In one plant they were used to check up the pressure and temperature of two large heating systems, both in the same plant. One system used steam and the other hot water.

Before installing the recording pressure gages and recording hot-water-temperature thermometers, complaints would be made, especially in severe weather, that heat was not available in distant places from the plant. When attendants were questioned about the lack of heat they would claim that the pressure on the steam system and the temperature of the water from the hot-water system were maintained as scheduled in their instructions, except for a short time when cleaning fires.

It was decided to install recording gages and thermometers. These were put into service during the day watch, and when the four o'clock watch reported, the man on the day watch being relieved called the relief man and was heard to say, "You better look out; the boss has put watchmen on us." Since then no further complaints have been received about lack of heat and the meter records are always close to the required schedule.

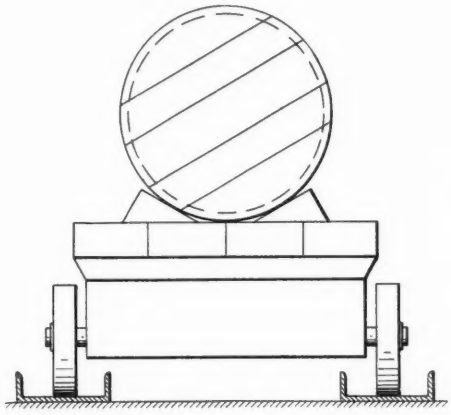
In addition to keeping accurate records without depending on makeshift written reports by men on watch in the plant, meters frequently make it possible to detect erratic operation or faults. In one case the recording temperature chart for the main steam pipe showed an irregular line or saw-tooth effect which was caused by a boiler priming. As another example, the temperature

of gases from the back pass of one boiler was much higher than that of the others. This is caused by holes in the back wall and baffles out of place.

A CO_2 machine is a good check on the condition of fires and warns the fireman of any trouble from holes in fuel bed or, as frequently happens, from automatic damper regulators that have become inoperative.

I have been supervisor for a number of years of a power plant that has twelve 6,000-sq.ft boilers with underfeed stokers, supplying steam for power generation, air compressors, pumps and for many other services. This plant is so equipped with recording flowmeters, pressure gages, thermometers, pyrometers and CO_2 machines that the records of each day's operation is complete. It requires only a short time each morning to tabulate the complete input and output, making it possible to have each day the exact results of plant operation. From the records and data available it is easy to detect anything unusual that may occur and to prevent a continuation of troubles that may eventually result in an expensive coal, water, or repair bill.

Portsmouth, Va. DAVID F. GWYNN.



Emergency Track Distributes Material Over Power-plant Roof

DUE TO space limitations, a recent boiler house addition to a central station was built somewhat higher than the original portion of the station. Part of the piping contract for the new addition included the erection of a new 24-in. steam main over the roof of the old station to connect the new boiler house with the existing turbine room.

The pipe, valves, and cast steel fittings of the new 24-in. steam main, designed for a working pressure of 400 lb. per sq.in., had to be distributed along the roof of the old station. A boom crane was erected on the roof at a point over the unloading area for incoming trucks so that the material could be hoisted to the roof for transportation to the points where needed.

Each piece of material weighed several tons. The roof construction of the old station seriously limited its allowable carrying capacity, causing the owners to forbid the use of rolls or dollies by the contractor in moving the new material. To meet these limiting conditions and to facilitate distribution of the heavy material, a double row of old 10-in. channel irons were laid flat on the roof as shown in the figure. The channel irons served as tracks for a four-wheeled flat truck and successfully carried all pipes, valves, and fittings without imposing dangerous strains on the roof structure. Enough channels were provided to form a track the entire length of the roof. The track was easily moved about to give access to any point where material was needed.

Arlington, Mass. T. W. BEAN.

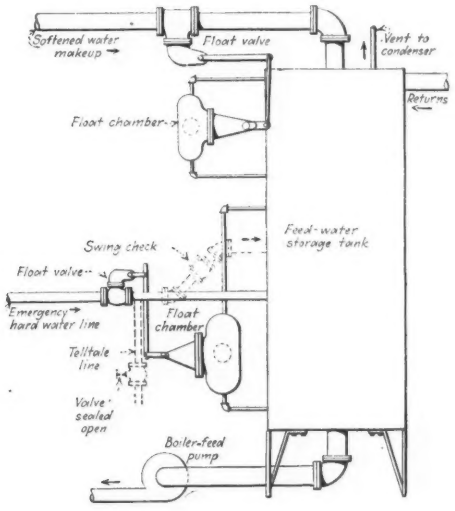
Preventing Hard Water Leakage Into Boiler Feedwater

SOFTENED feedwater for the boilers in a power plant of a mill was stored in a suction reservoir near the boiler-feed pumps. It had been the practice of the engineer to rely on the operators to open the valve on an emergncy raw-water line to this reservoir in case of any interruption in soft-water supply.

Some time ago it was decided to devise a more positive method of maintaining the feedwater supply than that obtained with manual control. An external pressure chamber containing a float was connected to the feedwater tank and to a lever-type valve in the emergency water line, as shown in full lines in the diagram.

Several months after the addition of the float-valve control the periodic boiler-water tests indicated that the boilers were getting hard feedwater. Examination of the float-operated valve showed a slight leakage, allowing hard water to mix with the regular soft feedwater. To protect the system against this a check valve was connected in the hard water line between the float valve and reservoir, as shown by the dotted lines. The line in which the swing check was connected was changed to a 45-deg. angle by the addition of two 45-deg. elbows.

A weight was brazed on to the under side of the swinging valve inside the check. This caused it to remain



seated tightly under its own weight in case of a low tank head on its pressure side, but when the float valve opened the check would lift easily. A $\frac{3}{8}$-in. telltale line was tapped into the bottom of the emergency line between the check and the float-operated valve. A globe valve was connected in this line and sealed open. If the float valve leaked it was indicated by a drip from the telltale line. In case of an interruption in the supply of softened water, the lead seal was broken after the float valve was opened, and the telltale valve closed.

Atlanta, Ga. W. R. MOORE.

CURRENT COMMENT

Another Slant On Pipe Welding

IN *Power,* December, 1932, W. J. Johnston describes the advantages of all-welded construction in pipe lines. Mr. Johnston finds everything in favor and nothing against the extension of this practice to piping of all sizes, services, and pressures.

Without questioning the figures in the graphs giving the comparative costs of flanged and welded fittings and joints I note that the author of "Welded Fittings" figured the time for welding a joint and for attaching a screwed flange to a pipe or bolting up of a flanged joint *at the same rate of pay.* This comparison might be considered unfair unless Mr. Johnston assumes that at the present "depressed" time one may find first-class welders willing to work for common laborers' wages.

Mr. Johnston further claims that "the metal of the walls (in commercial sizes of lap-welded pipes) is increased to compensate for threaded ends" and that "in the future the wall thickness will be decreased for a given working pressure or the present thickness will be retained and the working pressure increased." This claim would not bear analysis, remembering that any cylindrical internal pressure vessel requires only one-half of its wall thickness to guard against its failing transversely. As the standard pipe thread is never so deep as to cut half of the wall thickness, no increase need be made to compensate for the threading.

As points in favor of screwed or flanged joints and against all-welded construction may be cited:

(1) Greater flexibility. A pipe can be made to swing on its thread (within limits) without affecting its tightness. This condition is often taken advantage of in allowing for heat expansion in pipe lines.

(2) Ease of making repairs or alterations with almost any available labor at a plant. Additional branches, inlets or outlets, may be readily provided by replacing an existing elbow with a tee or a tee with a cross, etc.

It is not my intention to discourage the use of welding in piping work, but only to present both its advantages and disadvantages to the prospective user so that he may make a more judicious selection. The superintendent of a small plant that cannot afford on his working staff a first-class welder experienced in welding internal pressure vessels in accordance with approved welding specifications, would be wise to keep off welded piping as much as possible. To talk about welded lines never giving any trouble and requiring no attention or upkeep is simply to be over-optimistic. Certainly changes in arrangement of the various piping arteries in a progressive plant are likely to occur from time to time regardless of how carefully the lines are built.

Screwed and flanged piping construction is often unjustly blamed for bad judgment in the layout or erection of the lines. There are many cases where improper gaskets or make-up, inadequate provision for expansion and contraction, excessive vibration, etc., cause periodic leaks in pipe lines. The leaks disappear as soon as their cause is removed.

In conclusion, I wish to reiterate that this is no argument against welding in piping construction. I favored welding long before it came to be *in style.* My suggestion is only that individual cases should be considered according to their merits. Sweeping generalizations one way or another are apt to be misleading.

Pittsburgh, Pa. BERNARD KRAMER.

Paralleling A.C. Generators Without Synchronizing

THE article in the January number, "Paralleling an A.C. Generator Without Synchronizing," by Geo. P. Pearce, describes an interesting method for synchronizing without the use of additional instruments. It may be of interest to know that a company operating an extensive system used a method of synchronizing for restoring service which was simple and effective. A hydro-electric station with four 5,000-kva., 2,300-volt units was at times completely thrown out of step through system disturbances. To synchronize each unit separately was not only undesirable due to the load conditions but on account of the time required. To restore service in the shortest possible time the following method was resorted to:

The transmission circuits were disconnected and the field circuits were opened on all but one generator, which was operated at approximately 50 per cent excitation. The main oil circuit breakers were then closed on all units, and since the machines were revolving at approximately synchronous speed they pulled into step immediately, allowing the field circuits to be closed and the station synchronized with the system.

Some testing was at first required to determine the proper excitation to use on the active unit. When that was established, together with some other operations, the method was found to be satisfactory. Opening the field circuits and connecting the units to the incoming lines was tried, but due to the transmission system conditions and the fact that the units were slow-speed generators without damper windings on the rotor pole faces the disturbance was too severe.

New York City. C. O. VON DANNENBERG.

Increasing an Engine's Power by Increasing Its Speed

A CORRESPONDENT asks, in *Power* for February, how he may increase the power of his engine. One of the ways suggested for doing this is to increase the speed. This may be the only method over which the operator has control, but before the speed is changed the safety of the flywheel should be carefully considered. While there are many engineers who can calculate the safe speed of a flywheel, there are many, equally capable as operating engineers, who cannot do this. Such calculations ordinarily belong to machine design and do not come within the province of the operating engineer.

In one plant where I was employed, the superintendent

requested that we increase the speed of an engine driving the machines in one department. I was aware that the engine at that time was running at a higher speed than customary for engines of that type. After making some calculations of the working stresses in the flywheel, I was convinced that a further increase in its speed was not safe. There was some objection to my refusal to increase the speed, but it was soon forgotten. When the report came to me, some time after I had left the plant, that the flywheel of this engine had burst and caused considerable damage, I was not surprised. Before any attempt is made to increase the power output by increasing the speed of the engine, a careful check of the flywheel should be made. If the engineer cannot do this he should call in a representative of the engine builder for his advice. The stresses in a flywheel increase as the square of the speed, consequently a 40 per cent increase in speed will practically double the forces tending to cause the flywheel to fail.

Chicago, Ill. S. M. QUINN.

Causes of and Remedies for Flat Spots on Slip Rings

THE ANSWERS to the question on "Causes of Flat Spots on Slip Rings" in the January number cover most of the faults. My experience, however, has included a few more. Defective rings with hard or soft spots are not uncommon faults that I have found could usually be corrected by substituting rings of bronze or other alloys.

In one case, a grounded collector ring was the cause of flat spots. The source of direct current from which the exciting current was taken was grounded and the field switch opened only one side of the excitation circuit. When the generator was shut down and the field switch opened, there was still a circuit from the direct current source through the field coils to the ring with defective insulation and to the other side of the direct-current line. Each day the machine was shut down for 8 to 10 hours. During this period, because of the conditions just mentioned, the field current flowed from one spot on the ring to the brush. This caused pitting of that part of the ring which developed into a flat spot when the machine was in operation. The cure was to install a double-pole switch in the field circuit and insulate the ring.

Brooklyn, N. Y. C. O. VON DANNENBERG.

Smoke and Pure-Air Activities Are Not Marking Time

THE ARTICLE, "Smoke and Pure Air Activities Mark Time," in the January number of *Power,* conveys the impression that the campaign against contamination of the atmosphere by products of combustion has been practically at a standstill. While it is true that smoke abatement activities in cities have been somewhat curtailed, and in some instances have been stopped temporarily, there is ample evidence that "smoke consciousness" has increased. In many places people are asking if the future is to be permitted to be as clouded with preventable air pollution as was the past. In most cities the burning of the reduced amount of fuel is being supervised, and in some cases plans are being laid for the rehabilitation program which is ahead.

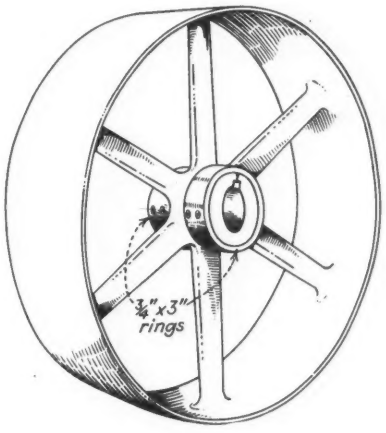
In the research field, certain workers are necessarily "marking time" because of the lack of financial support, but in other instances the work is going ahead. Among the latter is Mellon Institute of Industrial Research, Pittsburgh, through its air pollution investigation. Included in the activities for 1932 were: the completion and reporting of a year's record of natural ultraviolet radiation in Pittsburgh; the completion of twelve months' investigation, with continuous records, of carbon monoxide in Pittsburgh air, including a survey of conditions in a vehicular tunnel; determination, over the period of twelve months, of the amount of sulphur dioxide in the atmosphere at a central station. In addition, other investigations were carried along but not completed.

Mellon Institute of Industrial Research is not "marking time" in pure air studies; the same is true of others that have been devoting attention to research in this important field, although probably a lower proportion of the results have been published than normally.

Pittsburgh, Pa. W. A. HAMOR
Ass't Director
H. B. MELLER
Mellon Institute of Industrial Research.

Welded Rings on Hub Save Large Cast-Iron Pulley

THE ARTICLE "Adjustable Bushing Placed in Loose Pulley," reminds me of another pulley repair job. A 96x20 cast-iron pulley cracked through the hub over the keyseat. Welding the crack was tried, but it opened up after a few days. Two wrought-iron rings were then rolled and scarf-welded by the blacksmith. Each ring



was made from 3x¾-in. bar and of a diameter to fit tightly over the hub. Two ⅞-in. setscrews were put into each ring, as in the figure.

The rings were forced on the hub so that the setscrews were at right angles to the keyseat. When the rings were in place, the setscrews were tightened to close the crack under heavy pressure. A key, with about 0.1-in. taper per foot, had been used, and this taper evidently was the cause of the trouble. The repaired pulley has now been in service for about one year and has shown no signs of distress.

York, Pa. J. S. CARPENTER.

READERS' PROBLEMS

QUALITIES OF A GOOD LUBRICANT—*What are the properties of a good lubricant and what points should be considered in its selection?* C. J. M.

A good lubricant must have fluidity to form a lubricating film between surfaces and body to support and float a journal in its bearings. It must be of uniform quality and if used in a recirculating system it must have a minimum tendency to combine with impurities that may find their way into the system. If the oil is to be used but once and then run to waste, it must have a body to keep the waste at a minimum due to excessive leakage from the bearing, but it should not be so heavy as to cause fluid friction. Oil is selected for bearings according to its fluidity, or body, for average service conditions. In general, light-bodied oils are most suitable for light loads operating at high speeds and heavy-bodied oils are used for heavy loads operating at slow speeds.

FEEDING BOILER CHEMICALS—*I wish to ask for some information regarding best practice in feeding compounds to boilers. The plant I am referring to runs sometimes 8 hours a day, sometimes from 18 to 24 hours. The load on the boilers are heavy in the day time; that is, they are fired as hard as possible to supply the demand. At other times the load is light. Would it be better to feed the compound about 2 hours before blowing down or to add it to the feed water continuously during the operation of the boilers? We use only a small amount of lime and soda ash in our feed water for the boilers.* F. H.

(The following reply was prepared by W. J. Ryan, Water Service Laboratories, Inc., New York City—Editor.)

It is best to feed the compound continuously during the operation of the boilers. It does not seem necessary or advisable to feed any lime to the boilers. Lime is used in external treatment, as in a lime and soda-ash softener, to precipitate the bicarbonate hardness in the water, most of which is thus settled out and prevented from entering the boilers. However, nothing is accomplished by using lime for internal treatment, as the bicarbonate hardness will be precipitated anyway by the heat. The presence of the additional calcium caused by using lime merely increases the likelihood of a troublesome scale formation.

PROTECTION FOR IDLE BOILERS—*Why is sodium chromate added to boilers, heaters, etc., when they are put in storage for a long period? What strength solution is required to insure against corrosion? Is the same effect obtained by adding sodium bichromate and caustic soda as would be obtained by adding the chromate only? If so, what ratio of bichromate to caustic soda should be used?* T. B. R.

Sodium bichromate is used extensively in ice plants to retard corrosion in brine systems and is recommended for this purpose by the Corrosion Committee of the American Society of Refrigerating Engineers. Considerable care should attend its use because of its somewhat irritating and poisonous characteristics. It is stated, however, that with ordinary precautions there is little danger from chromates when concentrations of 200 lb. of chromate per 1,000 cu.ft. of liquid are not exceeded.

The recommended amount of sodium chromate to use with water as a first trial is 1 lb. per 10,000 lb. of water. Sufficient caustic soda should be added to the water to make it alkaline to phenolthalein (about .3 lb. of caustic to 10,000 lb. of water). Excess chromate above that required to stop corrosion should be avoided.

(The following reply to this question was prepared by W. J. Ryan, Water Service Laboratories, Inc., New York City—EDITOR.)

A solution of sodium chromate of the proper strength has the property of inhibiting corrosion. The amount of chromate to use with any particular water can best be determined by making tests with small clean pieces of steel immersed in solutions of various strength, to observe which specimen rusts most slowly.

Caustic soda is also used to inhibit corrosion. Caustic soda is probably the most satisfactory to use.

The A.S.M.E. rules for the care of power boilers contain the following:

"If idle boilers must be left with water in them in excess of a week, this water should first be boiled with the boiler properly vented for a short time to discharge all the gases possible from it and then made alkaline in excess of 50 gr. per gallon (850 parts per million) with caustic soda. For this alkalinity use 1.5 oz. of caustic soda per 100 lb. of water contained within the boiler.

"In cases where the water must be kept in the boilers a piece of clean bright steel should be hung in the closed boiler in such a manner that it can be removed and inspected for rust or corrosion at regular intervals.

"Where boilers filled with water are idle for long periods, great care should be used to keep this water cold, as the maximum amount of corrosion is promoted by lukewarm water. For this reason, feed valves and all steam connections should be tight at all times."

PARALLEL OPERATION OF ROTARY CONVERTERS—*We have two rotary converters that have operated in parallel for several years. Recently one of the machines developed a tendency to hog the load from the other. What might be the cause of the trouble?* A. P.

The most likely cause is poor connections. These connections may be in the equalizer switch contacts, between the terminals on the equalizer cable and the switch stud, in the soldered connections between the terminals and the cable, and the connections between the series-field coils or any others that may make up the equalizer circuit.

There also comes up the question of how the alternating-current voltage is balanced between the two rotary converters. It may be that due to poor connections or to other causes that this voltage on the two rotaries is not equal, particularly after a heavy short circuit has caused a large current to flow in a defective connection.

How Wound-Rotor Motors Can Be Started With a Compensator

Answers to the February Question

The Question

I HAVE several induction motors of the squirrel-cage and wound-rotor types, ranging in size from 50 to 150 hp. There is available a spare compensator of sufficient capacity to start the largest motor. In case of a failure of the starting equipment on one of the wound-rotor motors could its slip rings be short-circuited and the motor started with the spare compensator? If POWER *readers have had experience with starting wound-rotor motors in that way I would appreciate knowing how successful it was.* B.E.

Suggest a Water Rheostat for Starting the Motor

IT MAY be found many times that such a motor starts satisfactorily, but this is no proof that such a performance will be repeated indefinitely. Sooner or later the rotor will stop at a dead spot and refuse to start. If the motor is started manually, is within sight of the operator and can be turned over by hand before the motor is energized, the method of starting suggested by B.E. can be used in an emergency. It is important to have the motor rotating, no matter how slowly, before it is energized. If it is energized when stopped and is on dead center, frequently it will be found to be locked in this position and will resist being started by hand, either forward or backward, until it is de-energized. Unless the motor can be observed during starting, a slip-ring motor should never be started with the rings short-circuited.

If the regular starting equipment becomes disabled, almost any resistance capable of carrying a fairly heavy current can be substituted for the regular starting resistance, such as a water rheostat. Such a device can be made from an oil drum with the top end removed. Provide two electrodes of pipe or other metal. Connect one ring to the drum and the others to the two electrodes. Fill the drum with clear water, submerging the electrodes for about one-half the depth of water in the drum. Throw full voltage onto the motor stator. If the motor does not start, de-

energize it and dissolve a little common salt in the water. By experiment a combination can be found that will start the motor satisfactorily. When the motor is part way up to speed, the rings can be shorted by an ordinary two-pole switch of sufficient size, previously connected. Care should be used to insulate the oil drum and all parts of the water rheostat from ground as rotor windings are usually grounded at one point.

While this method allows but one step during acceleration, in most cases it can be used in an emergency. A refinement can be added by making the electrodes adjustable, up and down, gradually lowering them as the motor acclerates. On all but the smallest motors, which can be easily given a start by hand, it is believed this method will be found more satisfactory than trying to start with the rings shorted, on reduced voltage.

Kalamazoo, Mich. EARL E. NORMAN.

Connected Rotor Leads to the Motor Shaft

I HAVE started wound-rotor motors with a compensator on several occasions. We had several wound-rotor motors driving hoisting equipment on a large hydro construction job. Trouble was experienced in keeping the rings and rotors in operating condition. The hoist drums were all handled with clutches, consequently there was no need to vary the speed of the motor. As the motors were subjected to severe vibration and rough use, connections on the rotors worked loose, brushes became covered with gear dope and the rotors became partially open circuited and cause trouble.

To remedy this the leads were disconnected from the slip rings and connected to the rotor shaft with cap screws in tapped holes. One ring was usually grounded, so it was only necessary to ground two leads to the shaft, remove the brushes and then start the motors as squirrel-cage induction types.

Raymond, Alta. I. B. TUCKER.

Started Motors by Connecting Directly to the Line

WOUND-ROTOR motors can be started with a compensator or by connecting across the line if necessary. Where trouble occurs in the rotor circuit only, the motor can be started by disconnecting two of the resistors, place the controller handle to full-on position, raise the relay setting and close the line switch. To protect the motor, it will require lowering the relay settings, after each start, but this only takes a very short time.

Where trouble occurs in the stator circuit, some type of oil switch or compensator is necessary if the motor is of large rating. If a compensator is used, it is connected in place of the oil breaker. After the stator is energized, the motor is accelerated by the controller as formerly. When started in this manner, the relay setting of the compensator need not be changed. I have, on several occasions, started 550-volt motors up to 150-hp. by the methods described and have experienced no difficulty.

Port Arthur, Ont. H. E. STAFFORD.

Two Questions for Our Readers

Question 1

WE HAVE a number of belts that have developed a tendency to wabble across the faces of their pulleys. These belts appear to be in good condition, but I have been unable to make them run true. We have other belts operating under approximately similar conditions that do not wabble. Probably some readers can give their experiences with correcting such belt troubles. B. H.

Question 2

I EXPECT in the near future to be called upon to design a power line 1,200 ft. long to supply a load of nine 3-phase alternating-current motors totaling 870 hp. The power will be transmitted at 2,300 volts, 60-cycles, and stepped down through transformers to 440 volts for the motors. What size conductor will be required for the 2,300-volt line when installed in the open on insulators? Power factor will be about unity, as the load is about equally divided between synchronous and induction motors. Although the motors will all be operated at the same time, it is doubtful if they will all be fully loaded. In the design of a line of this kind, is allowance made for divirsity factor of the load? C.A.A.

Suitable answers from readers will be paid for if space is available for their publication.

Starting Will Depend on Character of Load

A WOUND-ROTOR motor with the slip rings shorted becomes essentially a squirrel-cage motor, and the same compensator of suitable size and type that is used for a squirrel-cage type may be successfully used for starting a wound-rotor machine. This does not always apply if the windings of the rotor are short-circuited at the ends of the slots. If this is done, the number of slots in the rotor may not be in the correct relation to the number of slots in the stator and may result in dead starting spots. If the motor should stop in a dead spot, the rotor may lock.

The character of the load must be taken into consideration. If it is such that a gradual acceleration is required, a squirrel-cage motor may not be suitable. On several occasions, however, I have successfully started slip-ring motors, having their rings short-circuited, with compensators.

Dalhart, Texas. W. L. COTTON.

Used 25-Hp. Compensator on 37-Hp. Motor

SLIP-RING induction motors are used mainly where it is necessary to start under load. If B.E. can arrange the drive so that the equipment may be started with little or no load, reduced voltage starting with the rotor rings short-circuited through the brush rigging will be satisfactory. Some slip-ring motors develop dead points at certain positions of the rotor when starting by this method. This may be overcome by turning the rotor by hand a few degrees before applying voltage. In some cases the starting load cannot be reduced sufficiently for starting with a compensator. The remedy then is to connect part of the starting resistance to the rotor and to short-circuit it with a three-pole knife switch after the motor has attained maximum speed.

We have a 37-hp. portable hoist which is being used as a winch for hauling freight cars in the yard. The control equipment was damaged, and while it was being repaired we short-circuited the motor rotor through the brushes and used a 25-hp. compensator for starting, with satisfactory results.

Delicias, Cuba. E. MOLINETT.

Used Compensator on Several Slip-Ring Motors

A COMPENSATOR may be used for starting slip-ring motors that drive line shaft and other equipment at a constant speed. To use the compensator it is necessary to short-circuit the brush-holders on the rotor. If it is intended to use the compensator for some time, it is advisable to remove the brushes and brush-holders and solder a strip of copper across the collector rings.

I have in a number of cases used a slip-ring motor for a year or more, operating as a squirrel-cage type. About two years ago I removed a controller and grids, connected to a 15-hp., 440-volt, 3-phase, slip-ring motor, short-circuited its rings with a copper bar, applied a compensator. I have never experienced any trouble with this motor. From my own experience, I believe B.E. should have no trouble in using a slip-ring motor with a compensator.

Pittsburgh, Pa. JAS. I. BALSLEY.

Motors Will Not Always Start Successfully

WOUND-ROTOR motors will not always start successfully on reduced voltage, with the rotor winding short-circuited. Motors of this type are generally used either to give a large starting torque, without excessive starting current, or for speed variation. The starting characteristics of such a motor with the rotor short-circuited will depend upon its normal running characteristics. If the motors have a start under heavy loads, then a compensator cannot be used successfully for starting.

I have attempted to start wound-rotor motors with a compensator, without success. The motors had to accelerate considerable loads consisting of geared triplex pumps. Attempts to start these motors on full voltage, with the rotor short-circuited, were also unsuccessful. B.E. can probably try starting one of his motors during a week-end. One or two rotor resistance steps can be left in circuit for a first trial and cut out one step at a time on successive trials.

Drummondville, Que. C. E. OLIVE.

How to Select the Right OIL BURNERS

By H. J. KLOTZ[1]
Ass't. Chief Power Engineer, Stone & Webster Engrg. Corp.

RECENT surveys have shown an increase in the known oil reserve, and it seems safe to assume that the production of petroleum may continue at increased rates for a considerable period. Nevertheless, the uncertainty regarding the future of oil supply makes it difficult to predict safely the proper price of oil for more than a year in advance. It is usually possible to obtain oil contracts for two and sometimes three years. Consequently, most oil-burning installations should justify themselves economically on the basis of retiring the investment involved in changing to oil during the period in which the oil contract is in force.

In designing new plants, and in considering the conversion from coal to oil, it is important to arrange the fuel-burning equipment so that a change can be made readily from the use of one class of fuel to another. This has resulted in the successful development of several makes of burners which are capable of burning pulverized coal and gas as well as oil.

During the early development of oil burners, attention seems to have been concentrated on producing good atomization. Good atomization, however, is only half the story in the production of a satisfactory oil burner. Provision must be made for combustion of the oil, and this requires that the oil atomizing or spraying element be combined with a device which supplies the proper amount of air under conditions that will result in thorough mixing of air and oil in proper ratios.

Practically all of the earlier oil burners were of the steam atomizing type, which in general gave good atomization and possessed the advantages of simplicity, ease of maintenance, and the requirement of a low oil pressure. The quantity of steam required in the best types of steam atomizers varies from 2 to 4 per cent of the steam output of the boiler. Mechanical atomizing burners were developed to avoid this waste of steam, which is of considerable importance in condensing steam power stations, where a low percentage of make-up water is desired because of the high rating at which boilers are operated.

Most of the early steam atomizing burners were used in furnaces where air was admitted by natural draft through checker work in the furnace floor. This resulted in poor mixing of air and oil and a consequent delayed combustion, with the result that both capacity and efficiency were limited. Mechanical atomizers have in general been used with air registers that admit the total air supply around the oil spray in such a way as to produce turbulence, thus promoting earlier and more complete combustion. Several manufacturers of steam atomizing burners now use air registers to admit air concentrically around the burner. This results in efficiencies close to that obtainable with mechanical atomization.

In the marine field, and for the high capacity stationary condensing plant, mechanical burners are preferred because of the desire to eliminate waste of steam. For the smaller plant, the higher efficiency obtainable with mechanical atomization must be balanced against the higher cost of pumping equipment and piping system required for supplying oil at pressures between 200 and 300 lb., necessary for mechanical burners.

Some grades of oil, when used in mechanical burners, require heating to between 275 and 300 deg. F., in which case the heating equipment is more expensive than that required with steam atomizing burners. Oil should be heated only high enough to attain a viscosity suitable for proper atomization, as heating much beyond that temperature usually results in producing objectionable carbon deposits in the heater.

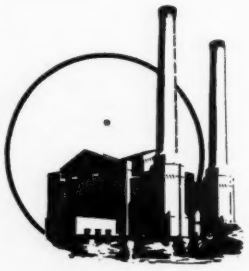
Burner capacities have increased by leaps and bounds. About five years ago, a burner with a capacity of 2,000 lb. of oil per hour was considered the maximum. Improvement in air supply has enabled a single burner to burn 5,000 lb. of oil an hour, or the equivalent of 100,000,000 B.t.u. per hour.

Many details, aside from the burner itself, are important in securing satisfactory combustion results. Proper control of the temperature and pressure of the oil is essential with mechanical atomizing burners. Thermostatic control of steam supply to heaters, to maintain a constant temperature, has proved desirable. The number of burners and the tip sizes of the burners in use must be varied to enable the oil supply pressure at the burners to be kept above the minimum required to produce proper atomization. Rotary type pumps are desirable for supplying oil to mechanical atomizers, in order to eliminate pulsations in flow.

All-refractory settings have given satisfactory results with oil firing at continuous rates of heat liberation up to about 4,000,000 B.t.u. per hour per foot of furnace width, and with comparatively short peaks up to rates of 6,000,000 B.t.u. per hour per foot of width. For continuous operation above 4,000,000 B.t.u. per hour some degree of wall cooling is desirable to lessen refractory maintenance expense.

The basis of heat liberation per foot of width is used rather than the more commonly used factor of heat liberation per cubic foot of furnace volume, as the latter figure is misleading when comparing furnaces of greatly varying heights. The lower portion of the walls of the higher furnaces required for large-capacity steam-generating units benefits to a decreasing extent from the cooling effect of the boiler heating surface as the height of walls is increased. Completely water-cooled furnaces, preferably with refractory-coated surfaces, are giving entirely satisfactory results with oil firing at all ratings up to the highest commercially attained.

[1]Abstract of "Oil Burning, Past and Present," presented recently before the Boston Section of the A.S.M.E.



SLAG-TAP FURNACES

By C. G. COLES

THE slag-tap furnace has many advantages. The idea of accumulating molten ash from pulverized coal as a puddle of slag in the bottom of a furnace has been a brilliant contribution to the art of steam generation. It avoids much trouble with slagging and clinkers on tubes, and makes low fusing temperature of the ash an advantage rather than a nuisance.

Slag-bottom furnaces will work with any type of furnace. Since the molten ash may be disintegrated with a stream of water, ash removal becomes simple and inexpensive. The first cost is low. These many advantages assure continually increasing use of this type of furnace.

Another characteristic of the slag-tap furnace is both an advantage and a disadvantage, depending upon the type of service. The layer of molten slag acts, obviously, as a heat reservoir, which otherwise is almost entirely lacking in the completely water-cooled modern boiler furnace. This heat reservoir reduces the speed with which changes of load can be made. On the other hand, changes of load in a water-cooled boiler without heat storage may be so rapid as to cause all of the water to disappear from the boiler drum when the output suddenly drops from the maximum to no load.

The unsolved problems relating to slag-bottom furnaces are concerned primarily with what happens within and beneath the slag. It has been hard to find a suitable material for furnace bottoms that is not permeable to the molten slag, or eroded by it. Chemical reaction and eddies in the slag play a part. When these bottom materials become saturated with slag, holes may occur through which the hot liquid will pour onto the basement floor.

In other cases, cooling of the furnace solidifies the slag. When the furnace is started up again, the resultant expansion may lead to serious difficulties with the side supports and failure may eventually occur. A dominating problem is the development of a non-expanding impermeable furnace bottom. Metallurgical engineers, from their long experience with similar problems, will ultimately meet these needs.

THE ENGINEER'S BOOKSHELF

High-Speed Diesels

HIGH-SPEED DIESEL ENGINES (1933). *An elementary textbook for engineers, students and operators, with special reference to aircraft and automotive types. By Arthur W. Judge, well-known British engineer. Published by D. Van Nostrand Company, Inc., 250 Fourth Ave., New York, N. Y. 248 pages, 5¼x8½ in. Clothboard covers. Indexed and Appendixed. 201 illustrations and diagrams; many tables. Price $3.25.*

Economy and other advantages have tremendously advanced the high-speed diesel as a successor to the gasoline engine, particularly for commercial transport. Practically speaking, the high-speed diesel was unknown commercially until 1927 or 1928; five years later enough work has been done to warrant a book about it. And the book is well and understandably written, supplying in elementary form the essential information of the research, manufacture and use of this type of engine, and indicating by means of extensive bibliographies where further information on any given topic may be found. It is of course incomplete on such subjects as combustion and efficiencies, principally because further experimental work must be done before definite conclusions can be reached. It is, however, a concise and carefully written compendium of the information thus far available, well illustrated and carefully handled.

Pumping Machinery

HYDRAULIC MACHINERY (1933). *By Daniel W. Mead, emeritus professor of hydraulic and sanitary engineering, University of Wisconsin. Published by McGraw-Hill Book Co., 330 West 42d St., New York City. Clothboard covers, 6x9 in.; 41 tables; 202 illustrations; 396 pages. Price $4.00.*

Hydraulic Machinery is somewhat of a misnomer as a title to this book, because it is more specifically a treatise on pumping machinery. Ten of its 17 chapters and 251 of its 396 pages are devoted to various types of equipment for pumping liquids. The remainder of the pages treat of energy conversion; energy of motion, efficiency of steam and internal combustion engines and other power equipment, all of which might well form part of a book on pumps.

The chapters dealing specifically with pumps are headed: Duty Units, Pumping Machinery—General Conditions, Direct-Lift or Bucket Pumps, Reciprocating Pumps, Work in the Cylinder of Reciprocating Pumps, Use of Steam for Pumps, Centrifugal Pumps, The Air-Lift Pump, Siphon, and the Hydraulic Ram. The book has been written from the practical designing and operating engineer's point of view. Emphasis has been placed upon the importance of knowledge of practical conditions and limitations to the designer and user, rather than on theory. Where mathematics have been introduced they are applied to practical pumping and power problems. Although the treatment is quite general, the book contains much to recommend it to those interested in pumping problems.

Electrical Yearbook

MECHANICAL WORLD ELECTRICAL POCKET BOOK. *Published by Emmott & Company, Ltd., Manchester, England. 1933. Cloth. Illustrated; 337 pages, 4x6 in. Price 1s.6d.*

This is the twenty-sixth edition of this little handbook. It contains a useful collection of data, suited to the needs of practical electrical workers, on electrical and magnetic units; direct-current and alternating-current generators and motors, and their operation; electrical calculations and power transmission and distribution; electrical measurements and testing and storage batteries.

Arc-Welding Design

DESIGNING FOR ARC WELDING. (*Second Lincoln Prize Competition Papers*). *Edited by A. F. Davis, vice-president of the Lincoln Electric Co. Published by the Lincoln Electric Co., Cleveland, Ohio. Cloth, 6x9 in., 416 pp., illustrated. Price, $2.50.*

Apparently, gold is an effective lure. Certainly the very impressive sum of $17,500, distributed as awards by the Lincoln Electric Co. in the Second Lincoln Arc Welding Prize Competition opened in September, 1930, inspired papers of extraordinary merit. Proof of this statement is contained in this book, which prints the prize papers. These are outstanding not merely as examples of clear presentations, but more particularly because of the solid technical contributions they represent. "Designing for Arc Welding" is divided into five parts, dealing with machinery, ships, steel structures, large containers, piping and fittings. Directly applicable in the power field are the papers on design details of arc-welded fan structures, arc-welded plate surface condensers for land use, arc-welded piping and pipe fittings, arc-welded steel expansion joints.

A.S.H.V.E. Guide

THE A.S.H.V.E. GUIDE, 1933. *Published by the American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York City. 6x9 in.; cloth; illustrated. 608 pp. of text, 108 pp. of catalog, 64 pp. membership roll. Price $5.*

Eleven new chapters are to be found in the 1933 Guide which is the 11th edition of this standard reference volume. Chapter 3, dealing with Heat Transmission Losses, contains an entirely new set-up of tables with coefficient of heat transmission. The new Ventilating Standard adopted by the Society in 1932 is included in Chapter 22 with other important data relating to air conditioning for health. Considerable heretofore unpublished information on duct design will be found in Chapters 24 and 25. A section describing test instruments and methods is new material as is also the data on Natural Ventilation in Chapter 36.

BRIEF REVIEWS

WELDING WITH MANUFACTURED, NATURAL AND MIXED GAS. *Report of an Investigation by the Engineering Experiment Station, Purdue University, Lafayette, Ind., in cooperation with the Utilities Research Commission. By H. H. Lurie. Published by the Station as Research Series No. 41. 116 pages, 6x9 in. Paper covers. Indexed. Price $0.50*—This investigation shows that insufficient heat, not sulphur content, limits the application of 550-1,000 B.t.u. gases for welding. Flame temperatures lie between 3410 deg. C. abs. (temperature of oxy-acetylene flame) and 2933 deg. C. (temperature oxy-hydrogen flame). Standard commercial torches will not handle these gases, so four new types were developed and are described. They produce favorable atmospheres in the welding zone and increase welding temperature 300 deg. C. Best welding is done on sheets up to ⅛ in. thick and on cast iron up to 1½ in. Steel up to ¼ in. has been welded, but not economically.

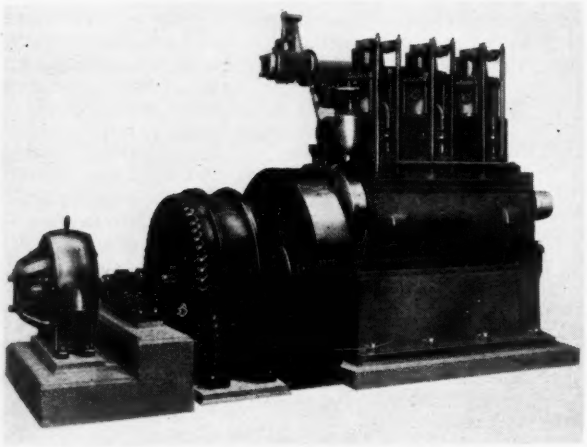
INVESTIGATION OF GROUND-WATER RESOURCES OF LONG ISLAND, N. Y. *By David G. Thompson and Francis G. Wells*—One of a series of investigations of various districts, all available in mimeograph form from the U. S. Geological Survey, Washington, D. C.

A TEST OF THE DURABILITY OF SIGNAL-RELAY CONTACTS (1933). *By Everett E. King. Published by the Engineering Experiment Station, University of Illinois, Urbana. Paper covers. 18 pages, 6x9 in. Price $0.10*—Results of a test which apparently indicates that in a relatively large percentage of the cases where relays have to be removed from service, the depreciation is due to weather and other causes rather than the behavior of the materials in the contacts themselves.

THE VALUATION OF PATENTS. *By George Hart Morse, E.E. For sale by the author at P. O. Box 271, Washington, D. C. 20 pages, 6x9 in. Paper covers. Price $0.25*—An exposition of the principles and methods of patent valuation, brought up to date, and published in convenient, easily readable form.

OHIO COAL INVESTIGATION. PART II, AN ECONOMIC STUDY OF THE USE OF CAMBRIDGE COAL WITH UNDERFEED STOKER EQUIPMENT. *By H. M. Faust. Published by the Engineering Experiment Station, Ohio State University, Columbus, Ohio, as Bulletin 75. Price $0.25.*—This investigation was performed with the cooperation of the Ohio Coal Investigation Committee, and graphs and tabulates results.

WHAT'S NEW IN PLANT EQUIPMENT



Improved Vertical Gas Engine

This improved line of vertical four-cycle gas engines is available with one to eight cylinders and 30 to 150 hp. per cylinder, thus giving units from 30 to 1,800 hp. (by combinations). Include common mixing valve adjustable through a single knurled handscrew (separate air and gas mixing valves independently adjustable for each cylinder are used in head of largest engines). Air inlet and exhaust valves carried in removable and interchangeable cages, exhaust valve cages being water cooled. Attached reciprocating pump circulates lubricating oil through main duct in base with cast-in branches leading to bottom of each main bearing. Camshaft is driven from flywheel end by spur gears with silent spiral teeth. Cylinder liners and heads readily cleaned through large handholes, and large openings to main and crank bearings provided with doors at front and rear. Convertible to diesels at moderate expense, by using fuel pumps and spray valves instead of magneto or battery and spark plugs, omitting mixing valves and using diesel cylinders with smaller valves in heads.

Worthington Pump & Machinery Corp., Harrison, N. J.

Re-Refining Equipment

Fabriform refinery, by proper heat application and steam agitation, produces controlled distillation with diluents being passed to expansion chambers from which they are expelled. Solids are trapped in filter chamber and used oil regains original color by heating to a controlled temperature as is done in original refining. Oil

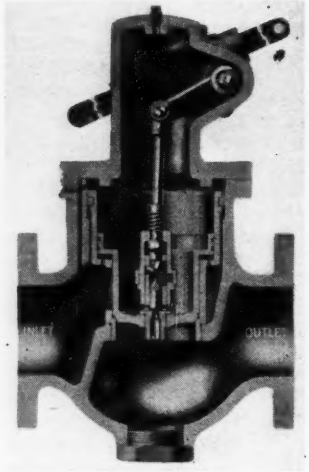
burner type unit uses diluents recovered from operation of refinery, thus running on its own waste material. Complete installation, angle-type thermometer, all-welded construction in accordance with A.S.M.E. boiler code, built-in initial heater and condenser, quick-acting filter chamber release for cleaning, pressure filter, no moving parts. Two models, R-10 with capacity of 10 to 15 g.p.h. and R-20 with capacity of 20 to 25 g.p.h. Either furnished for any type of heating.

Welded Products Co., Los Angeles, Calif.

Brine Treatment

Colloidal glucosides are used to control electrolysis by buffer effect in this H-O-H formula for controlling brine tank corrosion. Formula is adjusted to establish proper pH on initial treatment, and buffer action of glucosides maintains this pH over extended periods of time without frequent addition of material. Oxygen is eliminated through direct chemical combination. Treatment is effective in salt or calcium chloride brine and is also valuable for prevention and removal of lime and rust deposits from circulating brine systems.

D. W. Haering & Co., 565 W. Washington Blvd., Chicago.



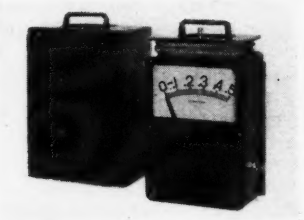
Pilot-Controlled Regulating Valve

Float on water level in tank, heater or other vessel to or from which flow is being controlled actuates small pilot valve, which controls pressure on plunger connected with main flow-regulating valve. Latter follows up motion of pilot, and therefore of float, without backlash or over-shooting, resulting in smooth variation of flow with change in position of float. An auxiliary multiplying lever enables small float with limited travel to control pilot accurately under high pressures, while retaining high lift of pilot and main valve. When closed, both main valve and pilot are held to seat drop tight by pressure, preventing leakage characteristic of so-called balanced valves. Dampening chamber prevents chatter. Rotary spindle can be on either side of valve body, giving eight different locations for operating lever.

Cochrane Corp., Philadelphia, Pa.

Dry-Type Pointer Draft Gages

Available in single and two-unit styles and for portable work as well as for wall and flush mounting, Hays dry-type portable pointer draft gages use no liquids and can be set up for service in 30 seconds. Black lacquer finished cast-aluminum case with glass window and slip-over metal cover. Carrying handle, tubing reel, and clips for carrying metal tube inserted in smoke pipe included. Overall dimensions, 5x4x9 in. Scale length, 3 in. Graduations in 0.01 in. of water. Screw for setting pointer outside case. Standard ranges, ½ or 1 in. water. Differential types can



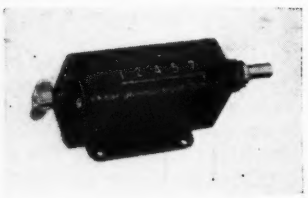
be supplied for indicating resistance, gas or air flow. For forced-draft stokers two-pointer gages with upper scale having range of +5 in. and lower scale +0.2 to 0 to —0.3 in. water offered. Other ranges for special applications.

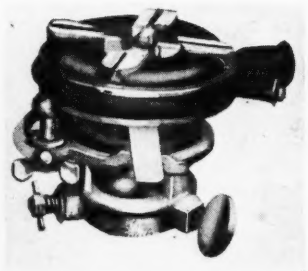
Hays Corp., Michigan City, Ind.

Resetting High-Speed Counter

This Veeder-Root high-speed resetting counter is of five-figure locked wheel type with all moving parts of hardened steel. Operates accurately in either direction at high speed. Reset to zero by means of single turn of wing nut and when resetting is started, must be continued until zero is reached. Will operate accurately at 8,000 counts per minute in direct-drive models, or to 2,000 counts per minute in revolution-type design. 4.09 in. long, 1.44 in. wide, 1.295 in. high.

Veeder-Root, Inc., Hartford, Conn.

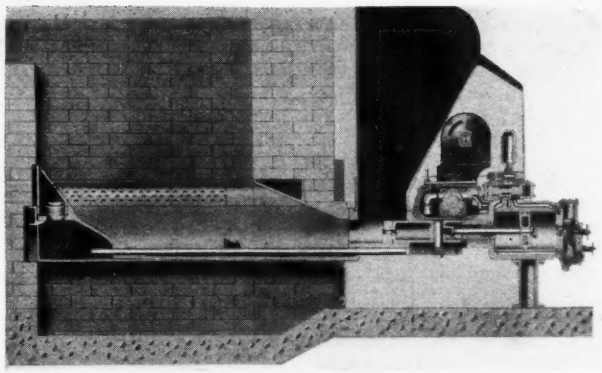




Ratchet Die Stock

No. 12R Beaver ratchet is a fully self-contained and adjustable 1- to 2-in. threader which is supplied complete with a set of dies. Ratchet drive ring is on die head to insure smooth operation, good threads and easy pulling. Dies are on top for easy oiling and chip clearance.

Borden Co., Warren, Ohio.



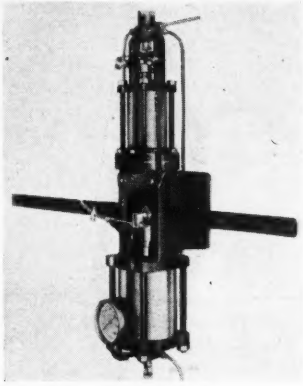
Underfeed Stoker

F&E underfeed stokers are available as heavy-duty type both in steam drive (No. 1265) and electro-hydraulic drive (No. 665), as standard type (No. 650), and with full front and no ram extensions or low front with ram extension (No. 545). Standard type is illustrated shown in detached blower and unit type arrangement. Automatic control head of unit regulates feeding of coal by increasing or decreasing interval of time between ram strokes. When ram operates it always makes full stroke at full speed. Hydraulic ram of enbloc type. Electric motor drives both heavy-duty rotary pump and direct-connected force draft blower. Standard unit has steel hopper with 750-lb. capacity. Can be tilted to one side to expose ram. Stoker surface consists of single retort with removable top tuyeres and grates of long cooling fin design, slicing bars and heavy sectional dumpplates. Multi-zoned wind box, treadle-operated clean-out doors, extra large ash removal doors, and automatic fire door lock of approved design. Features are (1) electro-hydraulic drive in three types operated by control head for governing frequency of ram operation, (2) motor mounted high above floor line and belted to heavy-duty rotary pump encased and operating in oil, (3) ram extension with moving hopper bottom on small stokers for heating boilers.

Flynn & Emrich Co., Holliday & Saratoga Sts., Baltimore, Md.

Dial-Type Indicator

No. 22 MJL dial-type indicator or gage provides reasonably priced instrument for accurate indication of rates of flow and differentials or may be used as level indicator to show liquid levels in tanks. Mechanically-operated, direct-reading type actuated by metal bellows in small chamber in rear of dial case. Large dial with large

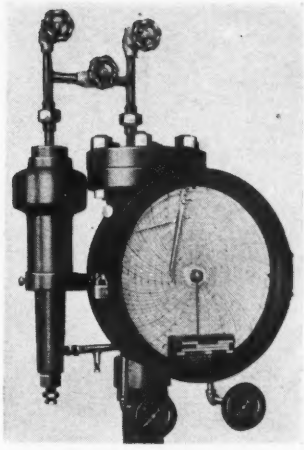


figures. Dial calibrations in inches differential or in g.p.m. of flow, or other direct readings for flow service. Simple mechanical connections to pointer arm. Suitable stops prevent injury to pointer under too great differential. Outside zeroing adjustment. 250 lb. per sq.in. maximum working pressure and differential pressures from 5 in. of mercury to 25 lb. Accuracy within 1½ per cent, even greater under high differentials. Indicator may be operated from any standard orifice, venturi tube, nozzle, or by other means.

Morey & Jones, Ltd., 922 S. Hemlock St., Los Angeles, Calif.

Flow Controller with Magnetic Clutch

TAG flow controllers utilize magnetic clutch instead of conventional pressure-tight bearing. This makes regular construction suitable for 2,500 lb. working pressure and immersion of all internal parts in mercury protects against moisture, dirt and corrosion. All internal parts including float are stainless steel. Clutch operates pen as positively as mechanical coupling and is claimed to provide greater accuracy. Low-pressure leg can be interchanged by user so that differential range can be made either 20, 50, 100 or 250 in. of water. A 100-in. range volumeter is also available which enables use of chart graduated uniformly in units of flow. Improved orifice-



holding ring with meter connections allows use of standard flanges; universal mounting for 2-in. vertical pipe or wall or panel mounting; monometer chambers of forged steel; stainless steel needle dampening valve adjustable during operation; improved stainless steel check valve; balancing control to prevent hunting; pilot valve instantly reversible from direct to reverse acting. Complete line of orifice meters is also available in this type.

C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

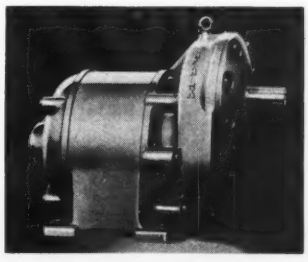
Packing Lubricating Compounds

These lubricants are furnished in 1, 2 and 5-lb. containers to be applied at intervals to packings of the company. Will lengthen life of packings in service. Full information from:

Greene, Tweed & Co., 109 Duane St., New York, N. Y.

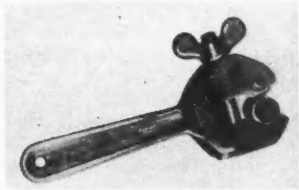
Geared-Head Motoreducer

Designed for relatively low ratios, both speed reduction and speed increase, this geared-head motoreducer makes possible use



of high-speed motors and provides any desired speed from one-ninth to about two and one-half times motor speed. Single-pair gear train provides variations and gives rigid and compact units. Low-speed shaft on Timken roller bearings. Eighteen standard reduction ratios available. Bulletin 261.

The Falk Corp., Milwaukee, Wis.



Tubing Cutter

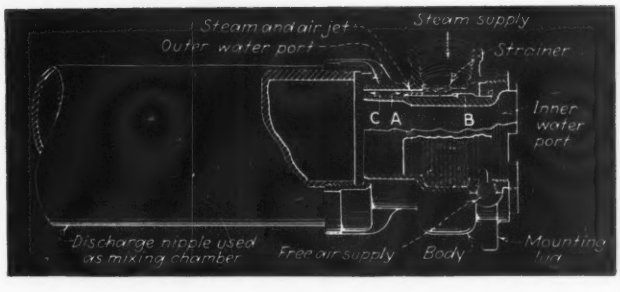
No. 100 Beaver tubing cutter cuts copper tubing from ⅛ to ¾ in. and produces clean square ends without burrs. A simple and low-priced tool.

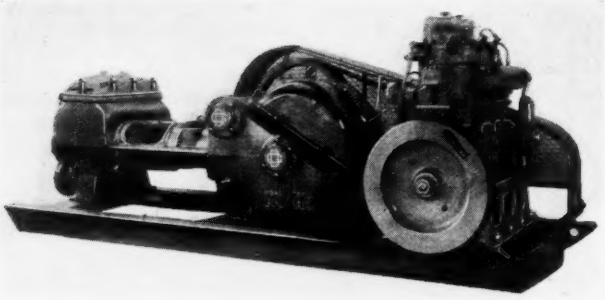
Borden Co., Warren, Ohio.

Steam-Operated Water Heater

This high-temperature, open-tank type Penberthy XL-32 water heater is used to heat water or other liquids to any temperature up to boiling without surging or pounding. Operating steam pressures range from 3 to 140 lb. at heater nozzle. Heating is accomplished by mixing steam with liquid to be heated in order to gain highest efficiency. Steam entering heater passes through strainer and is distributed in annulus *A*. When free air is used for greater quietness, steam rushing out of annulus *A* induces airflow through air inlet and annulus *B*. Steam expands in annulus *C* and flows into discharge nipple, causing liquid to rush in through outer and inner ports, thereby condensing steam and forcing active circulation of liquid to be heated. No moving parts. Bronze construction throughout. Jets easily removed for cleaning and built-in strainer protects steam annulus from clogging with scale. Capacities, 47 to 66,800 g.p.h.

Penberthy Injector Co., Detroit, Mich.





Diesel-Driven Power Pump

This 8x10 Gardner-Denver duplex-piston pattern self-lubricated power pump is connected by means of V-belt drive to a 20-hp. Hill diesel engine. Unit has capacity of 500 g.p.m. against total dynamic head of 115 ft. Pump and engine are mounted on welded steel H beam base sufficiently rigid for semi-portable use, or as base in simple foundation. Reciprocating pump has high mechanical efficiency. Slight feed changes while increasing or decreasing capacity do not affect efficiency. Available for pumping water, oil, gasoline, kerosene or similar liquids. Larger or smaller units available.

Gardner-Denver Co., Quincy, Ill.

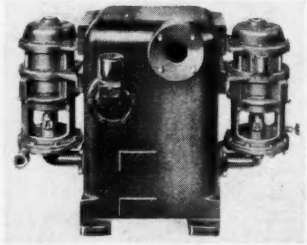
Plastic Masonry Mortar

"Cobbsment" plastic masonry mortar has low shrinkage factor, permitting it to be used for flue linings, chimney brickwork, or for boiler settings where temperatures of mortar do not exceed 900 deg. F. Waterproofed, high workability, high bonding strength and high compressive strength.

Glencoe Lime & Cement Co., 1608 Pine St., St. Louis, Mo.

Condensate Return Units

"Motorpump" condensate return units are used primarily for automatically returning condensation to boilers from low pressure, gravity-return steam-heating systems. Entirely self-contained, rugged in design, easy to install, and dependable. Unit conservatively rated to give pump large reserve capacity. Pump is Cameron Motorpump with built-in G.E. motor. Units available with either one or two pumps in sizes to handle up to 30,000 sq.ft. of direct radiation. Condensate reservoir is 15-, 30- or 60-gal. tank depending on size of condensation area. 15- and 60-gal. reservoirs of copper bearing steel and 30-gal. tank of cast iron. Unit illustrated has two 1-in. motorpumps on 30-gal. cast-iron receiver. If each motor is connected to a different electrical circuit, these duplex units provide protection against current and control failures and provide additional reserve capacity.



Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

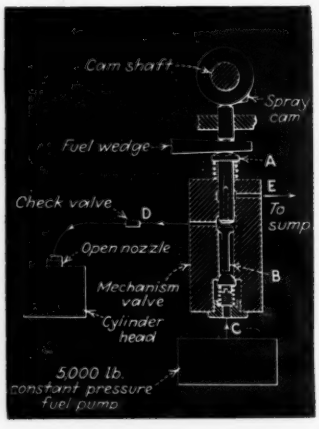
Tube Coupling

"Hi-Duty" tube couplings for copper, Shelby, aluminum, Bundyweld, Everdur, Monel and steel tubing have been patented, following several years of laboratory tests. Complete information in the Imperial Hi-Duty Data Book.

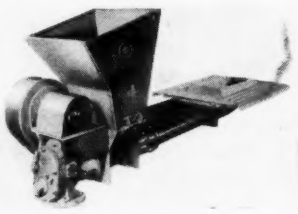
Imperial Brass Manufacturing Co., Chicago, Ill.

Diesel Fuel-Injection System

Cooper-Bessemer's new fuel system operates as follows: When cam opens valve, plunger *A* pushes against end of valve *B*, closes hole to center of plunger *A* through valve *B*, then goes through line *D*, through a check valve and into open nozzle in cylinder head. As soon as injection period is over spring under head of plunger *A* lifts it away from valve *B*, opening passes through center of plunger to atmospheric opening *E*. Check valve *D* in line prevents compression in cylinder from blowing any fuel back through nozzle. Any leakage past valve *B* has easy access to outlet *E*, therefore cannot cause smoke due to dripping. These valves can leak due to dirt or foreign substance up to full capacity of fuel pump before any effect is shown on engine. Mechanism easily accessible. Either spray nozzle or entire cylinder head can be removed without affecting timing of injection mechanism.



Cooper-Bessemer Corp., Mt. Vernon, Ohio.



Automatic Underfeed Screw Stoker

For boilers having 100 to 2,500 sq.ft. of heating surface. Has unusual design of motor mounting, permitting direct connection to forced draft fan and providing easily accessible and compact assembly. Variable speed transmission regulates coal feed. Provided with safety shearing pin. Chrome steel screw conveyor. Finished castings of heavy grey iron. Automatic electric controls for operating at predetermined boiler pressures. All working parts accessible.

Link-Belt Co., 2410 W. 18th St., Chicago, Ill.

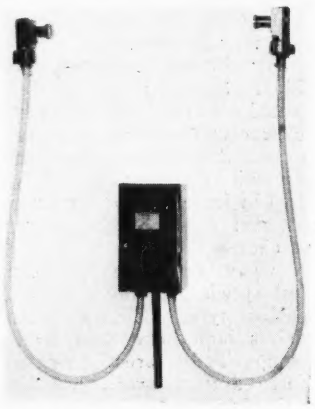
Two-Stage Opposed-Impeller Centrifugal Pump

This two-stage opposed-impeller centrifugal pump is for water supply in high buildings, small municipalities, industrial and process plants, etc. Of the ball-bearing, horizontal, split-case design, these units give high efficiency while operating at moderate speeds. Suitable for drive by motor, gasoline engine or steam turbine. Thick, stubby shafts give rigidity and insure quiet operation. 300-g.p.m. pump operating against 150-lb. pressure has shaft length of only 27 in. Compact construction saves floor space and weight. Bulletin 426 gives description, dimensions and head capacity tables.

Economy Pumping Machinery Co., 3431 W. 48th Place, Chicago, Ill.

Photoelectric Controller

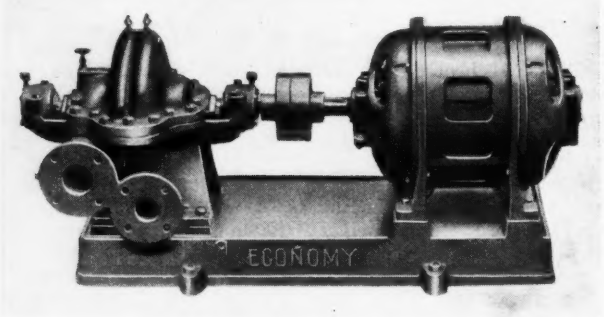
"Photo-Troller" light-sensitive controls are industrial devices actuated by phototube or delicate contacts carrying only a few micro-amperes. Phototube operates grid-glow tube directly which in turn closes contactor capable of initiating desired operation. Intermediate relays are eliminated. Assembled in sheet-metal cabinet with door and knockouts. Any commercial voltage or frequency, but not d.c. Includes complete power supply for all auxiliaries including light source which are available to operate at distances up to 22 ft. from tube. Housings are cast aluminum and available in splash-proof designs.

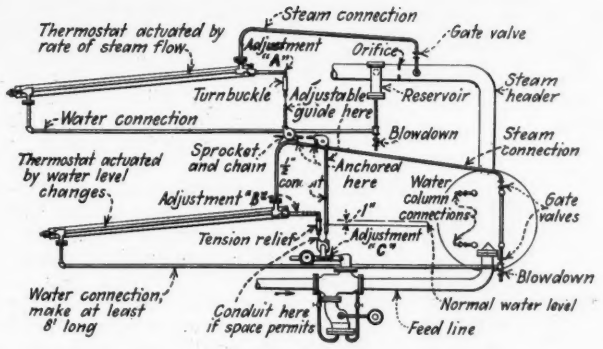


Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Improved Series-Type Feedwater Regulator

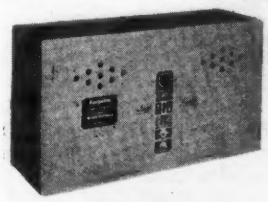
Copes series-type feedwater regulator has been improved as a result of tests at Bohlen Power Station, Germany. This regulator feeds boiler in accordance with steam flow, with com-





pensation for water level. New type of mechanical transmission makes it possible to locate steam flow thermostat near connections to steam header. This simplifies erection and adjustment of regulator, assuring more accurate results. Almost any desired proportion between steam flow and water level can be obtained without difficulty. Series-type regulator can be equipped with either direct-acting or hydraulically-operated control valve, or with a combined feed flow and water pressure regulating valve. Present installations of Regulators with tension-type thermostats may be changed over.

Northern Equipment Co., Erie, Pa.



Emergency Lighting System

"Keepalite" is a self-contained emergency lighting system which supplies a separate source of electric current to its own high-efficiency, low-voltage lamps. Consists of Exide battery, automatic relay, battery charger, switches and signal, assembled in compact metal case; also lamp fixtures and wide diffusion globes. Whenever normal power supply is interrupted, unit automatically and instantaneously lights protected areas of building, then shuts off automatically when power is restored. Battery trickle charged. Unit is 2 ft. 9 in. long, 10 in. deep and 16 in. high.

Electric Storage Battery Co., Allegheny Ave. & 19th St., Philadelphia, Pa.

Breaker with Oil-Filled Bushings

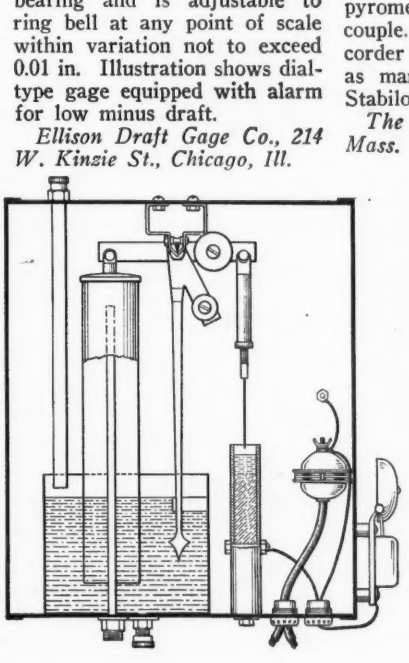
Rated 15, 25, and 34.5 kv., this line of circuit breakers is equipped with oil-filled bushings of a new type. By utilizing oil-blast principle of circuit interruption, breakers operate in eight cycles. Designated Type FHKO-339 for indoor and outdoor service, and have interrupting ratings from 500,000 to 1,500,000 kva. Breakers are of round-tank construction, one per pole. Three top domes are welded into single supporting plate. Mechanism entirely internal, eliminating any tendency to reclose during or after circuit interruption.

General Electric Co., Schenectady, N. Y.

Draft Gage Alarm

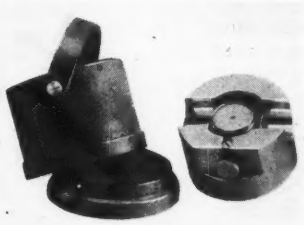
This sensitive electric alarm system for Ellison pointer draft gages can be furnished in either straight-line or dial-type pointer draft gages from minus, plus or differential readings, and for either high- or low-draft alarm. Transformer for either 220 or 110 volts, dry cells being used for other than a.c. current. System consists of transformer, bell, and mercury chamber and contact rod comprising switch. Chamber composed of hard fibre partly filled with mercury. Covered with oil for sealing electric arc against oxidation. Electric contact rod suspended on gage beam or knife-edge bearing and is adjustable to ring bell at any point of scale within variation not to exceed 0.01 in. Illustration shows dial-type gage equipped with alarm for low minus draft.

Ellison Draft Gage Co., 214 W. Kinzie St., Chicago, Ill.



Portable Vibrometer

For power plant, field and service work, and for general testing, this vibrometer is accurate and compact. Consists of flexibly supported mass and dial indicator fastened to end of thumb screw and supported by mass to measure amplitude. Vertical movements measured with adjustment shown, but for



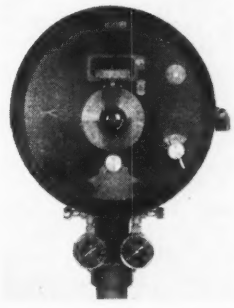
indications in other two principal planes dial indicator is turned through 90 deg. by means of thumb screw. Tests show vibrometer reliable for frequencies up to 6,000 r.p.m. when amplitude does not exceed 0.004 in., and at lower speeds for much higher amplitudes.

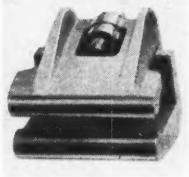
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

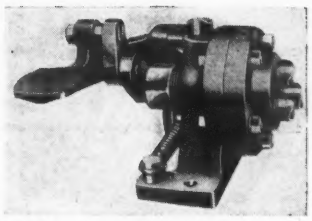
High-Temperature Automatic Control

"Potentiometer Stabilog," which combines advantages of Stabilog control and potentiometer temperature measurement is available for temperatures up to 2,800 deg. F.; also the long-distance potentiometer measuring system makes the instrument useful for remote control. If on lower temperature ranges, Wheatstone bridge and resistance bulb measuring system is used. Unit is non-recording, but record of its operation may be made on Foxboro recording potentiometer-pyrometer with same thermocouple. One multiple-point recorder may be hooked up with as many as six potentiometer Stabilogs.

The Foxboro Co., Foxboro, Mass.







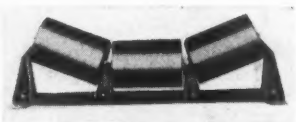
Foot-Operated Valves

"Nicholson" foot - operated valves are made in two, three and four-way types for use on air, steam, oil, water and gas lines. Include full bearing between disk and seat, permitting even wear and assurance against leaks, as well as steel stem supported by beveled socket and stuffing box. Model F-O illustrated has oscillating disk with no neutral position. On four-way type air pressure is always on one end of cylinder when pedal is up. When pressed down 30 deg. pressure is admitted to other end, and when released spring returns pedal to upper position. Exhaust port is arranged so when pressure is admitted to one end, other end is exhausting. Model F-R embodies ratchet on stem and rotating disk. Sizes, $\frac{1}{4}$ to $\frac{3}{4}$ in.

W. H. Nicholson & Co., 12 Oregon St., Wilkes-Barre, Pa.

Roller Bearing Idler

This Fairfield idler for belt-conveying systems uses Timken roller bearings. Available in both troughing and return roller types. Troughing idlers consist of three pulleys supported by malleable iron brackets and self-cleaning angle base. Demountable type pulleys; all three interchangeable. Return rollers are conventional flat one-piece. Three-fold labyrinth grease



seals with large grease reservoirs. Idlers built for belt widths from 14 to 60 in.

Fairfield Engineering Co., Marion, Ohio.

Fuse Clip Clamp

Ideal fuse clip clamps for knife blade fuses provide proper alignment and positive contact between fuse knife blade and the switch fuse blocks. Easy to apply and only two sizes needed from 100 to 1,200 amp. Clamp is simply slipped over switch fuse blocks after fuse is in place and fastened by lever action through machine screw illustrated.

Ideal Commutator Dresser Co., Sycamore, Ill.

POWER LINES

Internal-Combustion Engine Test Rules Internationalized

Preliminary negotiations have been completed which have resulted in the scheduling of a meeting in the United States next September of an international committee on the testing of all types of internal combustion engines. Known officially as Advisory Committee No. 19 of the International Electrotechnical Commission, this meeting will be held in the Engineering Societies' Building during the week of September 11-16 inclusive.

The revised Commercial Standard for Fuel Oils, sent out under date of Dec. 5, 1932, hereafter identified as CS12-33, has been accepted by the majority of oil refiners, distributors, and consumers, and will be considered effective beginning May 1.

Welding Meeting Will Feature Business Leaders

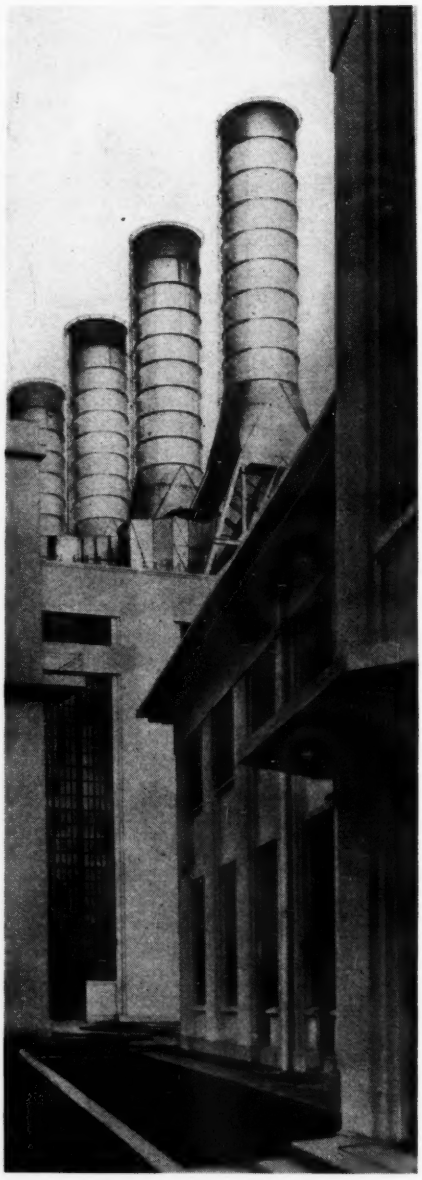
Departing radically in character from all its previous national meetings, the Annual Meeting of the American Welding Society, to be held at the Hotel Governor Clinton in New York City, April 27 and 28, will subordinate discussions of technical details and feature broad-gage full-length addresses by business and engineering leaders.

These speakers will be Prof. Frank P. McKibben, president of the American Welding Society and nationally known engineering leader in the field of structural welding; Charles F. Abbott, executive director of the American Institute of Steel Construction; Col. Willard Chevalier, publishing director of "Engineering News-Record" and "Construction Methods."

In his address, to which a special evening session will be devoted, Professor McKibben will summarize present conditions and future possibilities in the field of structural steel welding. A special session on Friday morning will be devoted to the addresses of Mr. Abbott and Colonel Chevalier.

Mr. Abbott, speaking on the subject "Must Industry be a Power or an Influence," will stress the need for cooperative industrial effort under changing conditions. Addressing the Society on the subject of "Welding—A Factor in Industrial Revival," Colonel Chevalier will lay down the conditions that must be met by any progressive industry under conditions that are immediately ahead. He will show how these conditions may be capitalized by the welding industry to expand the use of welding and incidentally to contribute to the industrial revival.

Other features of the meeting will be the report of the Pressure Piping Code Committee by T. W. Greene, chairman, the report of the Committee on Use of Welded Steel Parts for Machinery Construction by G. D. Spackman, chairman, and the usual meeting of the American Bureau of Welding, C. A. Adams, director, presiding.



Gas washers at the new Arrighi station, Paris, are located beneath the two diagonal crosses in the breeching

Paris Combats Smoke Problem

The usual winter pall of smoke and gas over the City of Paris were missing this year, according to a correspondent. This was largely a result of the Official Condemnation of Smoke Nuisance of the Chamber of Deputies, passed April 21, 1932. This law forbids noxious admissions from chimneys of domestic and commercial establishments alike, providing heavy fines for violations. The law gives government services one year in which to comply with its tenets and private establishments three years.

The problem has been attacked in several ways. St. Lazare station, formerly handling 485 steam trains a day, now handles 930 electrified ones. River boats are diesel powered. One large utility company has constructed 500 modern apartments without a chimney, to be occupied by workers, and to use electricity for all services including cooking. They will take power at off-peak periods. Five super-power stations with a total capacity of 1,250,000 kw. around the town have been equipped with gas purifiers. Equipment for this service has been built in without affecting the beauty of the stations. The Arrighi station (formerly called Vitry Sud) has small inexpensive washers located beneath the two diagonal crosses in the breeching shown. Known as the Modave-Hanrez washer, the unit passes gas from the induced draft fan through hollow vertical cast-iron columns, substantially square with concave faces, placed six rows deep with alternate rows staggered. Water pours over the top, covering the outside with a constantly renewed liquid film. Some 90 to 96 per cent of the grit is removed, together with most of the sulphur, with a draft loss of $\frac{1}{8}$ to $\frac{3}{8}$ in. water gage.

Engineers' Economic Conference

The third annual session of the Economic Conference of Engineers will be held this year from August 12-20 at Stevens Institute of Technology's engineering camp, under the sponsorship of the Institute and Columbia University.

Washington Gets Hydro Power

At noon, March 3, the steam-driven generators in the Benning's power plant of the Potomac Electric Power Co., and the hydro turbines driven by the Susquehanna River in the plant of the Safe Harbor Water Power Corp., were brought into parallel operation, a switch was closed at the new transformer station at Takoma Park, and the Nation's Capital received its initial supply of hydro-electric power. A 230,000-volt transmission line connects the systems.

Safety in 1933

The problem of protecting workmen from accidents has engaged the leading minds in business and industry for many years. As one of the most important agencies in this field, the Greater New York Safety Conference met for its Fourth Annual Meeting March 1 and 2 in New York City. Sessions were devoted to all angles of the safety problem in many fields of industry.

Dr. J. J. Whittmer, medical director of the New York and Brooklyn Edison Companies, detailed first-aid methods with and without first-aid kits. Dr. H. C. Parmelee, vice-president and editorial director of the McGraw-Hill Publishing Co., outlined the relation of the industrial press to safety progress. Respirators and gas masks were discussed under the leadership of W. P. Yant, superintendent, Experimental Station, U. S. Bureau of Mines, Pittsburgh, Pa. E. W. Gorry, Superintendent, Operating Department, United Electric Light & Power Company, reviewed post-depression plans for effective accident prevention work.

Appalachian Coal Decision Handed Down by Court

The decision of the Supreme Court of the United States in the Appalachian Coals, Inc., case, handed down by Chief Justice Hughes, March 13, has opened new vistas on the Sherman anti-trust law. Appalachian Coals Inc., was incorporated in 1932 as an exclusive selling agency to handle the output of 137 producers in eight high-volatile coal fields in Kentucky, Tennessee and Virginia. Its membership represented 54 to 64 per cent of the commercial production of the territory. Following formal incorporation, the Department of Justice sued to have the company dissolved as a monopoly. The case was heard last summer. After decision, it was appealed to the Supreme Court, where arguments were heard in January. The court found that there is no warrant for challenging the good intentions of the defendant, although "good intentions will not serve a plan otherwise objectionable," and that conditions in the coal industry make it "impossible to conclude that defendants, through the operation of their plan, will be able to fix the price of coal in the consuming market." "There is no ground," say the court, "for holding defendant's plan illegal merely because they have not integrated their properties, and have chosen to maintain their independent plant, seeking not to limit but rather to facilitate production."

Coal Conference Postponed

The Sixth Midwest Bituminous Coal Conference has been postponed until 1934, due to unfavorable economic conditions, according to the sponsors.

A.S.T.M. Committee Meets on Coal Classification

The annual meeting of the Sectional Committee on classification of coal, functioning under A.S.A. procedure, and sponsored by the A.S.T.M., was held recently in New York City.

A joint meeting of Subcommittees on the Determination of Grindability and Friability of Coal, and of the A.S.T.M. Committee D-5 on coal and coke, was held prior to the meeting. A report was presented, which gave final results of the investigation on the use of absorption of dyes for determining increased surface produced by grinding coal. In general, the method is not suitable for comparing different coals, but it does give a measure of increased surface produced in further grinding of the same coal.

Mr. Gilmore presented a report of the work done during the past year in the Fuel Research Laboratories of the Mines Department of Canada, and described a method developed for evaluating and comparing laboratory grindability methods.

Bureau Establishes Clearing House for Hydraulic Research

More than 24 American institutions—governmental, university and business—dealing with hydraulic research, have accepted an arrangement whereby the U. S. Bureau of Standards will act as a clearing house for Hydraulic Laboratory research information. Under this arrangement, which was promoted by O. C. Merrill, chairman of the American Committee of the World Power Conference and by the Department of Mechanical Engineering of the University of California, the Bureau will collect quarterly reports of research from the cooperative institutions. All records and reports received will be filed at the Bureau and there made available for study.

Summaries of the reports will be mailed quarterly to the cooperating institutions. It is expected that the Bureau will also serve as a contact point with similar agencies in other countries.

Boiler Bills Advocated

Among bills regarding boilers introduced in various states are these: House bill 21 in Indiana which would prohibit welding and provides that no one but boiler makers can qualify as boiler inspectors; and House Bill 676 in Minnesota which would require inspection of high-pressure piping construction. The Indiana bill passed the house, but is held up by the Senate.

Trevithick the Bold

One hundred years ago this month died Richard Trevithick, pioneer engineer. Newcomen invented the low-pressure condensing engine. James Watt perfected it by adding the outside condenser, but kept steam pressures down to 4 or 5 lb. gage. This third Englishman, Trevithick, turned to "high-pressure." His 100 lb. or thereabouts led the way to modern steam practice.

Using his high-pressure engine, Trevithick built and operated the first automobile ("road carriage") in 1801. Two years later he built and ran the first practicable locomotive. Many other inventions and engineering exploits marked his career.

Fittingly to honor the centenary of Trevithick's death, a number of British technical societies and organizations are backing a public appeal for funds with which to erect suitable memorials. Coutts & Co., 440, Strand, London W.C.2, England are acting as treasurers for the fund.

World Power Conference Will Emphasize Industrial Power

The 1933 Sectional Meeting of the World Power Conference, opening at Stockholm in July, will emphasize industrial power problems. About 40 of the reports to be published at the meeting will deal with energy supply in large-scale industry, with particular stress on combined production of heat and power.

Special subjects covered include: High-pressure industrial turbines, heat and power in breweries, bleeder turbines in breweries, surplus energy from sugar factories, gas turbines, process steam from secondary hydro, power developments in the pulp industry, energy problems of the iron and steel industry, oil engines, co-operation of hydro and steam.

Among the papers supplied by the American committee, of which O. C. Merrill is Chairman, will be "Electric Heating in the United States," by R. M. Cherry (General Electric Company), and J. G. Woodson of Westinghouse, "Coordinated Production of Industrial Steam and Utility Power," by H. R. Smith of General Electric, "Energy Requirements of the Aluminum Industry," by T. J. Bostwick of the Aluminum Company of America, "Recent Industrial Gas Developments," by the American Gas Association.

Summer Management Course

The 18th annual summer management course of Pennsylvania State College will be held June 7-15.

COMING MEETINGS

Sixth Midwest Engineering & Power Exposition — Coliseum, Chicago, Ill., during "Engineering Week," June 25-30, of the Century of Progress Exposition. Headquarters, 308 W. Washington St., Chicago, Ill.

American Society for Testing Materials—Annual Meeting, The Stevens, Chicago, Ill., June 26-30. C. L. Warwick, Sec.-Treas., 1315 Spruce St., Philadelphia, Pa.

Nat'l Ass'n Power Engineers—National Convention, in conjunction with Niagara Frontier Power Conference & Mechanical Exposition, Buffalo, N. Y., Auditorium, Aug. 28—Sept. 2. Fred W. Rayen, Secretary, 1140 Lake St., Oak Park, Ill.

American Welding Society—Annual Meeting, Engineering Societies Building, 29 West 39th St., New York, April 27-28. M. M. Kelly, Secretary, above address.

Canadian Electrical Ass'n — 43rd Annual Convention, June 14-16, Log Chateau, Lucerne-in-Quebec, Canada.

Second American Exposition of Brewing Machinery, Materials & Products—Auditorium Hotel, Chicago, Ill., Sept. 23—Oct. 1, together with meeting of Master Brewers Ass'n of American. James R. Nicholson, 55 West 42nd St., New York, N. Y., secretary. Felix Mendelsohn, managing director of exhibit.

PERSONALS

F C. KERNS, superintendent of lubricating sales of the Texas Co., has been elected director of the Fuel and Ash Group of the Exhibitors Committee Industrial and Power Shows, Inc., 330 West 42nd St., New York, N. Y., an organization composed of manufacturers interested in industrial exhibitions and shows. During the six years of its existence, the committee is claimed to have saved at least $200,000 for its members and other exhibitors at these shows. Among other things, it influenced the change in the schedule of the New York and Chicago Power Shows which are now held biennially in place of the former annual.

ARTHUR E. BLACKWOOD has been elected chairman of the board, and Henry S. Beal has been elected president of Sullivan Machinery Co., 400 N. Michigan Ave., Chicago. Mr. Beal has been with the Jones & Lamson Machine Co. since 1929, latterly as general manager. Arthur E. Blackwood has been with Sullivan since 1897, and has been president for the past four years.

CHARLES L. CLARKE, retired G.E. employee and one of the Edison pioneers, has been presented with a medal commemorating his charter membership in the A.S.M.E. He became a member of the Society in 1882. He was at that time chief engineer of the old Edison Electric Light Co., and was assisting in the equipment and layout of the historic Pearl Street station.

R. H. GARRISON, formerly general sales manager for the Universal Motor Co., Oshkosh, Wis., has become vice-president in charge of merchandise for Marble-Card Electric Co., Gladstone, Mich. The company manufactures a complete line of a.c. motors up to 100 hp., and d.c. motors up to 75 hp.

CLARK T. MORSE, formerly vice-president of the American Blower Co., Detroit, has been made president. James Inglis, former president, becomes chairman of the board. H. E. Barth has been made general sales manager. Mr. Morse has been with the American Blower Co. since 1912,

entering the company as manager at a Montreal office. In 1916 he was made manager of the Chicago office, and in 1923 made sales manager, and later vice-president.

EARL C. SMITH, chief metallurgical engineer, Republic Steel Corp., addressed a meeting of the A.S.S.T. at Muncie, Ind., March 1, on "Alloy Steels from the Manufacturer's Viewpoint." He spoke on the same subject at meetings of the A.S.S.T. at Buffalo, N. Y., on March 8, and at Rochester, N. Y., on March 9.

FREDERICK L. RAY of Anderson, Ind., past president of the N.A.P.E. and well known in power engineering circles for many years, has been appointed a member of the new Anderson Board of Education which is planning a "clean up" of a difficult school situation in that city.

GEORGE C. MCMULLEN has become manager of industrial sales for Tyson Roller Bearing Corp., Massillon, Ohio.

JOHN H. SMITH, formerly with Westinghouse and connected with the condenser industry since 1910, has been appointed vice-president of Condenser Service & Engineering Co., Inc., with headquarters at 61 Broadway, New York City.

W. P. THOMAS has been elected president of the Diamond Power Specialty Corp., Detroit, Mich., and of Diamond Specialty, Ltd., Windsor, Ont., to succeed Norman L. Snow, who died Jan. 27. Mr. Thomas has been associated with Diamond for 17 years as chief engineer, secretary and vice-president.

BUSINESS NOTES

H. T. WEIS, inventor of the Weis de-slagging apparatus described in the March issue of *Power*, p. 141, has joined the Diamond Power Specialty Corp., Detroit, Mich., and will assist in the sale and development of this device, which supplements other de-slagging equipment already being manufactured by this company.

GEO. H. THOMPSON has been appointed New England representative for the Swartwout Co., 18511 Euclid Ave., Cleveland, Ohio. His headquarters will be at 58 Brookline St., Cambridge, Mass.

CHAIN BELT CO., Milwaukee, has appointed R. L. Harrison Co., Inc., Albuquerque, N. M., as distributor in that area. A. S. Kennedy has been appointed manager of the company's new branch office in Kansas City.

REFRACTORY & ENGINEERING CORPORATION, 381 Fourth Ave., New York, N. Y., has purchased the former plant and equipment of the Merion Magnesia Corp., Valley Forge, Pa. The new plant, as well as the present plants at Bayway and Netcong, N. J., will be used for the manufacture of new insulations developed by the company.

GEORGE P. REINTJES CO., Kansas City, Mo., has appointed R. G. Hess, 25 Church St., New York City, as agent in the New York district.

LUDLOW VALVE MFG. CO., Troy, N. Y., has appointed the J. W. Frazier Co., 626 Western Reserve Bldg., Cleveland, as representative in northern Ohio.

RILEY STOKER CORP., Worcester, Mass., has established an Indianapolis office headed by B. J. Schneider, 420 Continental Bank Bldg., Indianapolis, as its head. Sales in the Chicago territory will be handled by Messrs. Hardin, Oswald and Moyer. C. L. Smith continues his association with that office at 1101 Marquette Bldg., Chicago, Ill.

More than 250,000 man-hours of work will be provided by construction of the eight Hoover Dam cylindrical intake gates at the Westinghouse East Pittsburgh plant. Each of the massive cylinders will be 32 ft. in diameter and 8 ft. high and will weigh 240 tons. About 4,000,000 lb. of steel castings, arc-welded plate, bronze, copper, and Monel metal will be used in the gates, which are to be welded in segments and assembled at the dam.

STRONG, CARLISLE & HAMMOND CO., Cleveland, Ohio, has been made national distributor for the Lenney variable-speed transmission in sizes up to 1½ hp.

PATENT & TECHNICAL INFORMATION SERVICE, 1336 New York Ave., N.W., Washington, D. C., has instituted a service making available to manufacturers and research workers technical information which may be of use to them in solving current problems, including making searches through patent records and securing technical data in various government bureaus.

I. C. DEHAVEN ENGINEERING CO., 1125-27 Circle Tower, Indianapolis, Copes representative for the last 10 years, has been assigned all of northern Indiana, with the exception of Porter, Lake, La Porte, St. Joseph and Elkhart Counties.

ECONOMY EQUIPMENT CO., Roosevelt Bldg., St. Louis, has been assigned all the State of Illinois south of the 40th parallel.

KIELEY & MUELLER, INC., 34 W. 13th St., New York City, has appointed United Equipment Corp., 245 S. Third St., Columbus, Ohio, as representative in the State of Ohio (except the Cleveland district) and in eastern Kentucky and the western part of West Virginia. E. H. Bollenbacher, Atlanta, Ga., has been appointed representative in the States of Georgia, Florida, Alabama and eastern Tennessee.

OSTER MFG. CO., Cleveland, Ohio, celebrated recently its 40th anniversary, and the third of its merger with Williams Tool Corp., Erie, Pa. Although the individual corporate names, Oster Mfg. Co. and Williams Tool Corp. will not lose their identity, the combination will henceforth be known as Oster-Williams, Cleveland.

PLIBRICO JOINTLESS FIREBRICK CO., 1800 Kingsbury St., Chicago, has appointed John S. Hayes as distributor at Toledo, with headquarters at the Baier Transfer & Storage Co., 347 S. Erie St.

THE HYDRO-ASH CORP., 115 S. Dearborn St., Chicago, has elected the following officers: James Stokoe, president, Ernest E. Lee, vice-president, Geo. W. Hansen, secretary, and John L. Higgins, treasurer.

OBITUARIES

FREDERICK W. PARSONS, 66, vice-president of Ingersoll-Rand Co., died at his home in Corning, N. Y., April 1, after being ill for several weeks. He had introduced several vitally important changes in air compressor manufacture, and was manager of several of the company's plants.

ANDREW CAMERON PEARSON, 60, chairman of the board of the United Publishers Corp., New York, publishers of *Iron Age*, *Automotive Industries* and other technical journals, died at his home in Montclair, N. J., March 31.

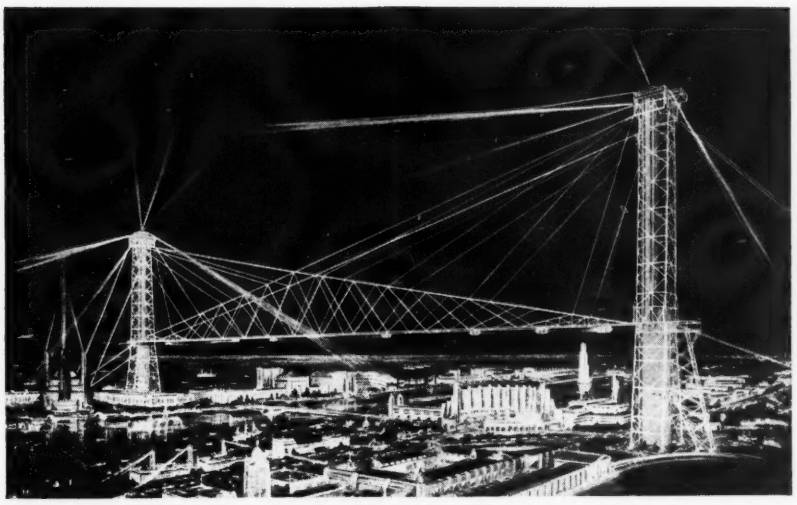
H. G. BARNHURST, Middle West representative of the Cement Sales Department, Babcock & Wilcox Co., and well known for his activities in the early development of pulverized fuel, died of heart failure March 18.

CHARLES EDWARD EVELETH, 57, vice-president of the General Electric Co., died at Schenectady, March 25, following an illness of several months. He had been with the company since his graduation from Worcester Poly in 1899, and vice-president since 1927. He had more recently had charge of the designing engineering departments and of the works laboratories.

ADAM W. FRANCE, 65, president of the France Packing Co., Philadelphia, died at his home March 8. He had been ill for the past two years. Mr. France founded the company 37 years ago, and has had approximately the same personnel and organization for the past fifteen years. J. A. McPeak, former treasurer, has been elected president.

WM. ARTHUR ROSSELL, 52, assistant northeastern district manager of the Westinghouse Electric & Mfg. Co., and an authority on generation and distribution of power, died suddenly March 8, at his home in Summit, N. J.

R. M. STANLEY, 57, electrical engineer, Byllesby Engineering and Management Corp., Chicago, died March 7 at his home there.



Each of the two 625-ft. Skyride towers at the Century of Progress Exposition, Chicago, will include four automatic, high-speed Otis elevators. Two elevators will travel from the ground to the rocket-car stations, the other two will go on up. A bird's-eye view of an elevator system in operation will be provided at the tops of the towers, and visitors may look through shatter-proof glass panels down hoistways.

The Cover

FIVE new plants of 1933, each concrete evidence that power is a basic necessity, for only essential projects are being built today. These are:

1 Cincinnati Union Terminal, Cincinnati, Ohio. Supplies steam for heating terminal, roundhouse, standing trains and for direct-steaming of locomotives, compressed air, treated and wash water. See pages 186-187.

2 Meadowbrook and Nassau County Public General Hospitals, Hempstead, N. Y. Supplies steam for heating, sterilizing, refrigeration, hot and cold water. Two Heine water-tube boilers, each 5,440 sq.ft. 160 lb. pressure, 175 per cent rating. Fired by Todd oil-burners, three per boiler.

3 The Hill School, Pottstown, Pa. Supplies steam for heating, cooking and laundry, hot and cold water, electric power and light. Two 3,610-sq.ft. Edge Moor boilers, 125 lb. pressure, Taylor stoker fired. Two uniflow (1 Kingsford, 1 Ames) engine-driven generators, one 150 kw., the other 125 kw.

4 Queens General Hospital, Jamaica, N. Y. Supplies steam for heating, sterilizing, cooking, laundry, electric light and power, refrigeration, hot and cold water. Four 3,890-sq.ft. Union water-tube boilers, fired by Todd oil burners, three per boiler. All equipment in duplicate, including main steam and feedwater lines. Two 250-kw., one 125-kw., generators.

5 General Electric Outdoor Mercury-Steam Installation, Schenectady, N. Y. Supplies steam for power and process, electric light and power. One mercury boiler and one 300,000-lb. per-hr. steam boiler. Steam, generated at 400 lb. and 750 deg., operates a 6,000-kw. turbine. Mercury at 125 lb. and 958 deg. F. operates a double-flow, 20,000-kw. turbine. See *Power*, February, 1933, page 34.

STRAWS

Pointing the way the business wind blows

Bids will be asked soon for steam power plant and central heating system by the Construction Quartermaster, Patterson Field, Fairfield, Ohio, estimated to cost about $150,000.

State Legislature, Bismarck, N. D., is discussing a measure for construction of a steam-operated electric generating plant at the State Penitentiary. Proposed to provide a fund of $335,000 for station, including underground conduit system.

Luray, Va., is investigating the possibilities of a municipally-owned plant. Its present rate is 10 cents a kw.-hr. for light.

The Great Western Sugar Co., Denver, has placed an order for a 1,500-kw., 80 per cent power factor, turbo-generator unit for its Billings, Mont., sugar factory, with Allis-Chalmers Mfg. Co.

Ontario Paper Co., Thorold, Ont., opened March 10 its 90,000-kw. electric boiler installation, which operates from surplus power.

South River, N. J., for many years advertised as the "municipality without taxes," reports a net profit from operation of municipal electric power plant of $91,-016.17 in 1932, as compared with $96,943.32 in 1931, despite the fact that there was 10 per cent less energy used last year.

Two new electric boiler installations in Canada will consume only "off-peak" power. The Canadian Car & Foundry boiler, of 5,000 kw. capacity, will develop steam for process work. The Ste. Justine Hospital boiler, of 2,500 kw. capacity, will provide steam for the hospital. Both boilers will operate 24 hours daily during the six summer months, and 12 night hours in winter.

A constitutional amendment to make the State of Washington a giant power district has been introduced, the amendment providing the State retain in perpetuity control of all water-power development and power sites, organize a state hydro-electric commission and develop power, separately or in conjunction with other states of the United States. The amendment, its sponsors claim, will permit the State to undertake the Grand Coulee Dam project.

Board of Public Works, Seattle, recently awarded to the Allis-Chalmers Mfg. Co., Seattle, contract for two pumping units for the 17th N.E. pipe line, to be equipped with 200-hp. motors.

Morenci, Mich., plans early call for bids for municipal electric light and power plant and waterworks system. Estimated cost $145,000. Ayers, Lewis, Norris & May, Ann Arbor, Mich., are consulting engineers.

The City of Tacoma, Wash., will spend about $132,000 in 1933 for construction and improvement work, and $117,000 for maintenance of power plants and appurtenant structures. Ira S. Davisson is commissioner of public utilities.

J. D. Ross, superintendent of lighting at Seattle, Wash., plans to open bids some time in April for construction work at the Skagit power site and completion of Diablo power plant. Officials are trying to obtain a loan of $1,625,000 from the R.F.C., and New York financial interests are ready to take $2,354,000 of city light utility bonds to furnish funds for redeeming warrants aggregating $1,854,000 now outstanding for work already performed and also $500,000 to finance extension of the distributing system.

Consolidated Public Utilities Corp., Westminster, Md., has been purchased by Consolidated Gas, Electric Light & Power Co., Baltimore. The purchase has been approved by the Maryland Public Service Commission. The entire price, according to papers in the case, is approximately $500,000.

According to City Manager I. G. Vass, of Waynesboro, Va., that city has effected a saving of $3,800 in electrical pumping cost and other items during the past year with the new city water system installed a year ago.

New Bulletins

TUBE EXPANDERS AND CUTTERS—Gustav Wiedeke Co., 1833-1903 Richard St., Dayton, Ohio, has issued Ideal Catalog No. 57 describing the company's complete line of tube expanders and tube cutters for all types of locomotive and stationary steam boilers, heaters, condensers, refinery stills, etc. The catalog is bound in board covers and is unusually complete in illustrations.

MINIATURE STEAM GENERATORS—"Comm-O-Lectric" electric-heated miniature steam generators are described in Bulletin No. 52 of Commonwealth Electric & Manufacturing Co., 83-105 Boston St., Boston, Mass.

ROTARY DISPLACEMENT PUMP—A rotary displacement pump designed to run at standard motor speeds or even at turbine speeds is described in Catalog L-10, published by the De Laval Steam Turbine Co., Trenton, N. J. The catalog lists pumps of this design for capacities ranging from 4 to 460 g.p.m. and for pressures up to 200 lb., and shows pumps for pressures in excess of 500 lb. per sq.in.

LEFAX DATA—New inserts for booklets of Lefax (Inc.), Philadelphia, Pa., include: "Banding Wire Sizes for Armatures and Rotors," "Methods of Computing," and "Materials Used in Chemical Engineering Operations."

TURBINES — GEA-1656, "Speaking of Records," of the General Electric Co., Schenectady, N. Y., describes performance records of four G-E mechanical-drive turbine installations and lists information on a number of others.

TEMPERATURE REGULATORS—Sarco Co., Inc., 183 Madison Ave., New York, has issued a bulletin on its temperature regulators for heat control in industry.

CONDENSATION PUMPS—Type "G" vertical Ames condensation pumps are described in Bulletin 800 of Ames Pump Co., Inc., 30 Church St., New York, N. Y., a division of American Locomotive Co.

EFFECTS OF TREATMENT ON METAL—Adam Hilger, Ltd., 98 Kings Road, Camden Road, London, N.W.1, England, has issued a booklet on the X-Ray metallurgical crystallograph for X-ray examination of the effects of heat and mechanical treatment on metals.

OIL CIRCUIT BREAKERS—Roller-Smith Co., 233 Broadway, New York, has issued Catalog No. 6 describing Type 0 indoor oil circuit breakers.

NICKEL CAST IRON—International Nickel Co., Inc., 67 Wall St., New York, N. Y., has issued a guide to the selection of engineering specifications for grey iron castings. A series of tabulations of nickel and nickel-chromium cast iron compositions is included in the four 8½x11 in. pages.

TENSILE TESTING MACHINE—The Oxweld portable tensile testing machine is described in a 15-page illustrated 6x9-in. booklet, published by Linde Air Products Co., 30 East 42nd Street, New York. A 7-page illustrated booklet describes also the Oxweld Extensometer, Type TM-3.

VARIABLE-SPEED TRANSMISSION—Reeves Pulley Co., Columbus, Ind., has issued Bulletin T-5645 describing Reeves variable-speed transmission and has the title, "Automatic Variable-Speed Control."

LUBRICATION—Acheson Oildag Co., Port Huron, Mich., has issued technical bulletin No. 102.3 describing lubrication of small mechanical devices.

"HOW TO OBTAIN COMFORTABLE ECONOMICAL HEATING"—A 16-page booklet by Commodore Heaters Corp., 11 West 42nd St., New York, describes Convectofin built-in heaters.

STEAM PUMPS—Worthington Pump & Machinery Corp., Worthington Ave. at Warren St., Harrison, N. J., has issued this series of bulletins on direct-acting steam pumps of the horizontal duplex piston type: Bulletin W-101-S1, "General Services" (capacities from 35 to 320 g.p.m.); Bulletin W-101-S2—Oils up to 350 deg. F.; W-101-S3—General Services, capacities from 6 to 230 g.p.m.; W-101-S4—Oils up to 350 deg. F., capacities from 31 to 240 g.p.m.; W-101-S5 and S6—Handling Oils up to 650 deg. F.; W-101-S7—For condensate return service; W-102-S1—Turret type for general services; W-102-S2—For larger capacities; W-103-S1—Pot-valve style; W-103-S2—Oils up to 700 deg. F.; W-103-S3—General service pot-valve style; W-103-S4—Pot valve, outside end-packed plungers for boiler feed and pressure service; W-103-S5—For oils up to 350 deg. F.; and W-103-S6—For oils up to 700 deg. F.

New Plant Construction

McGraw-Hill Business News Department Is Prepared to Furnish a More Complete Daily Service

Ark., Springdale—City Council made application to Reconstruction Finance Corp. for $30,000 loan to finance construction of and equipment for municipal light and power plant. Pending action by the corporation on application the city has not yet retained a consulting engineer to draft plans for proposed plant. F. D. Watson, mayor.

Calif., Burlingame—City plans power plant. $73,500 for land and buildings. $480,000 for engine and generators and $187,000 for distribution system.

Ill., Genesco—City voted to construct municipal light and power plant. $200,000. Warren & Van Praag, Inc., Milliken Bldg., Decatur, engrs.

Ill., Heyworth—City, Bd. Local Impvts., E. O. Washburn, pres., soon takes bids municipal light and power plant, $62,000. Warren & Van Praag, Decatur, engrs.

Ill., North Chicago—City Council completed survey municipal lighting plant. Neiler, Rich & Co., 431 South Dearborn St., Chicago, engrs.

Ind., Auburn—City making plans remodeling waterworks and electric light plant. $15,000.

Ia., Morning Sun—City will probably vote soon on establishing a light and power plant payable from earnings. H. L. Cory Co., 1033 Redick Tower, Omaha, Neb., engrs.

Ia., Rockford—City voted favorably to establish a light plant payable from earnings. $105,000. H. L. Cory Co., 1033 Redick Tower, Omaha, Neb., engrs.

Ia., Wapello—City will probably vote soon on establishing a power and light plant payable from earnings. H. L. Cory Co., 1033 Redick Tower, Omaha, Neb., engrs.

Ia., Winfield—City will probably vote soon on establishing power and light plant payable from earnings. H. L. Cory Co., 1033 Redick Tower, Omaha, Neb., engrs.

Mass., Holyoke—Bids Apr. 12, by City, J. J. Kirkpatrick, Electric & Gas Dpt., City Hall, addition, alterations, incl. additional equipment to turbine building.

Mass., Taunton—City, Municipal Light Dpt. plans altering and constructing addition to generating station, West Water St., also additional equipment for same. A. L. Nelson, 31 St. James Ave., Boston, engr.

Mass., Winchendon—Town, F. E. Morlack, chn. Bd. Selectmen, plans municipal lighting plant. Committee to be appointed by selectmen, to investigate project and report. Engineer not appointed.

Mich., Morenci—Village, plans prepared for municipal waterworks system and electric light plant, incl. generating equipment, switchboard equipment, wire and conduits, distribution system, 100,000 gal. elevated steel water tank, pumping equipment and wells. $140,000. Ayers, Lewis, Norris & May, Ann Arbor, engrs.

Neb., Columbus — Business interests are behind a movement to construct a hydro-electric dam, 20 mi. canal and power plant to generate 20,000 kw. of energy about 3 mi. north of here. To be financed partly through Reconstruction Finance Corp. loan. Bill authorizing organization of District has been presented to legislature now in session at Lincoln.

N. J., Clifton—Forstmann Woolen Co., F. L. Bradley, in charge, 2 Barbour St., Passaic, 1 story, 40x70 ft., brick, steel addition, to boiler house. Randolph Ave., separate contracts. $28,000 with equipment. Private plans.

N. J., Jersey City—Standard Laundry Co., 985 Garfield Ave., 1 story, basement, brick power plant and wash room addition, 963 Garfield Ave., separate contracts. Est. about $28,000 with equipment. R. G. and W. M. Cory, 30 Church St., New York, archts.

N. J., Newark—Bd. City Comrs., City Hall, plans 3 story, basement, 128x300 ft., brick, steel, limestone sports arena, ice palace, etc., Raymond Blvd., Commerce and Mulberry Sts. $500,000. **Maturity soon.**

N. J., Perth Amboy—Maguire Corp., c/o G. M. Ricci, archt., 175 Smith St., bids in May, general and separate contracts 3 story, basement, 55x100 ft. brew house; 1 story, basement, 100x225 ft. bottling plant, 1 story, basement, 35x75 ft. boiler and engine room, on Maguire St. $150,000.

N. M., Hatch—City plans improving water system, including pumping unit. $20,000 Reconstruction Finance Corp. loan applied for. H. O. Ganst, Las Cruces, engr.

O., Dover—Municipality plans extensions and alterations to power plant. To exceed $40,000. W. Hartline, c/o owner, archt.

O., Fairfield—Con. Q.M., Paterson Field, bids early in summer, heating plant at Paterson Field. $160,000.

O., Maumee—City sketches municipal electric light plant. $150,000-$200,000. City now receiving proposals from contracting firms.

O., New Washington—Village preparing survey 1 story, light plant, $50,000; distributing system, $25,000. F. N. Straus, 2613 Queenston Rd., Cleveland, engr.

Okla., Cushing — City, J. W. Flint, mgr., making preliminary estimates 1 story, basement, 52x75 ft. municipal electric power plant and distribution system. $300,000. N. W. Ward, city engr.

Okla., Millerton—Bids Apr. 25, by Purchasing Officer, Dpt. Interior, Wash., D. C., complete construction central heating plant, incl. all equipment and underground distribution system with final connections to all buildings at Wheelock Academy.

Pa., Pittsburgh—City plans changes and repairs to pumping stations, repairs to concrete revetment, Ross Pumping Station, $3,500; new pumping unit at Mission St. Pumping Station, $15,000; repairs to building at Mission St. Pumping Station, $5,000; new boiler feed pump and standby fan, $8,500; sand for filter beds, $8,000***electrification of Herron Hill Pumping Station, $127,000. C. M. Reppert, City County Bldg., engr.

S. D., Aberdeen—Election Apr. 18, $975,000 bonds for municipal electric power plant and distribution system. Bemis Co., 105 West Adams St., Chicago, Ill., engrs.

Tex., Burkburnett—City municipally owned power and light plant, incl. distributing system, large dynamo unit, etc. $25,000.

Tex., College Station—Bids Apr. 15, by A. & M. College, c/o S. G. Bailey, secy., College Station, 1 story, basement, brick, rein.-con. addition to power house. F. E. Giesecke, College Station, college archt.

Tex., Plainview—City plans purchase of present privately-owned power plant, and would make improvements and additions, etc. $100,000. Montgomery & Ward, Harvey-Snider Bldg., Wichita Falls, engrs.

Va., Radford—City Council plans electric power system, incl. dam across Little River, 750 kw. power plant. $129,000. Reconstruction Finance Corp. loan approved contingent upon permit from Federal Power Comn.

Ont., Cornwall—J. C. Meadocroft, Cornwall, archt., soon takes bids for new ice arena, for Syndicate, composed of C. C. Munro, J. D. Watt, C. Parisien, H. Clark and C. J. McTavish. $60,000.

Equipment Wanted

PUMPING EQUIPMENT — **Brookline, Mass.** —Town, D. A. Rollins, chn. Bd. Selectmen, plans deep well and furnishing pumping equipment for same. $10,000 appropriation granted.

PUMP—**Russell, Mass.**—Town, W. O. Johnson, chn. Water Bd., Town Hall, 1 story, concrete, brick pumping station, electric pump, installing several driven wells. $4,000.

PUMPING STATION EQUIPMENT—**Detroit, Mich.**—Dpt. P. Wks., plans prepared by J. S. Stringham, city engr. and item included in budget for additional equipment for Fairview Pumping Station, to provide for burning fuel oil under boilers. $13,600.

PUMP, etc. — **Northport, Mich.** — Village plans prepared waterworks system and tourist park, incl. deep well, to be 6 in. with 200 g.p.m. pump against 150 ft. head. Application to Reconstruction Finance Corp. for $33,000 loan. P. H. Beauvais & Associates, Manistee, engrs.

PUMPS—**Austin, Minn.**—City will purchase and install by day labor two 1,200 g.p.m. electric motor driven pumps. J. C. Todd, secy. Water and Light Bd.

BOILER—**Salem, Ore.**—State Emergency Bd., Salem, appropriated $15,000 for new 300 hp. heating boiler to replace present installation at state penitentiary. Total $30,000. W. Einzig, state purch. agt.

PUMP — **Seattle, Wash.** — City completing plans constructing Dakota Street Sewage Pumping Plant, and 2,000 g.p.m. pump with 15 ft. head with 12 deep and 12 in. wide concrete pit for housing. City Eng. Dpt., City-County Bldg., engrs.

TURBINES, GENERATING PLANTS, etc.—**Morrisburg, Ont.**—Morrisburg Village Council, F. R. Chalmers, clk., plans extensive repairs to either the upper or lower existing plants in village to have generating plant increased to over 300 hp. Village open for bids for turbines—generating plants or diesel engine, as recommended by engineer when he makes his report. Engineer not appointed.